IDA

INSTITUTE FOR DEFENSE ANALYSES

Distance Learning and the Reserve Components

J. Metzko
G. A. Redding
J. D. Fletcher

December 1996

IDA Document D-1941

Log: H 96-004086

This work was conducted under contract DASW01 94 C 0054, Task T-L2-1374, for the Office of the Under Secretary of Defense (Personnel and Readiness). The publication of this IDA document does not indicate endorsement by the Department of Defense, nor should the contents be construed as reflecting the official position of that Agency.

INSTITUTE FOR DEFENSE ANALYSES

IDA Document D-1941

Distance Learning and the Reserve Components

J. Metzko
G. A. Redding
J. D. Fletcher

PREFACE

This report documents an analytical effort performed under a task entitled "Total Force Distance Learning Assessment." An earlier version of the report was used by the staffs of the Office of the Deputy Under Secretary of Defense/Readiness (ODUSD/R) and the Office of the Assistant Secretary of Defense/Reserve Affairs (OASD/RA) to identify and evaluate Service plans to adopt Distance Learning (DL) technologies. While the analytical findings have not changed, substantially more evidence—discussion and citations of numerous studies—of the effectiveness and cost effectiveness of DL technologies has been added in this expanded report, the data of which were current through FY95.

Two staff members of the Office of the Secretary of Defense deserve grateful recognition for their suggestions and encouragement throughout the development of this report: Mr. Gary Boycan, ODUSD/R, and Commander Lorrie Rezendes, USNR, formerly in OASD/RA before reassignment to Headquarters, Naval Sea Systems Command.

CONTENTS

TABLES

FIGURES

EXECUTIVE SUMMARY

The Deputy Secretary of Defense tasked the Services on 27 October 1994 to review Distance Learning (DL) technologies[1]—print, videotape, computer-based training, interactive videodisc/compact disc, and video teletraining—and to submit plans by 31 July 1995 for using them to train their reserve component (RC) personnel. The Assistant Secretary of Defense for Reserve Affairs subsequently requested data to assist the Office of the Under Secretary of Defense for Personnel and Readiness in evaluating the Program Decision Memorandum (PDM)-directed Service plans.

FINDINGS

The following findings are derived from a review of the Service DL plans submitted in response to the Deputy Secretary of Defense tasking and from the ongoing joint-Service review of training technology and Service training requirements initiated early in 1994:

DL Has the Potential to Provide Effective Training, Reduce Costs, and Improve Military Readiness

- *More than 300 studies* have demonstrated the efficacy of DL technologies in the military, academia, and the commercial world. DL is as effective as conventional resident instruction in achieving a wide range of instructional objectives (Section III.A, Appendices).
- Many cost-effective applications of DL technologies—i.e., computer-based training, interactive videodisc, compact disc and video teletraining—have involved active component (AC) personnel and DoD civilians in schoolhouse courses. Thus, besides delivering DL to the RCs, these technologies could be used to train AC personnel (1.6 million) and DoD civilians (900,000) *either at a distance or in residence* (Section III.A).
- DL can be used to train those who, for whatever reason—usually a lack of funds—are unable to travel to resident training sites. DL could be used to train

1 Distance Learning (DL) is structured learning that takes place without the physical presence of an instructor. In this paper, DL is a generic term used to refer to distance learning, distance training, distance education, distributed training, distance instruction, etc. DL technology includes the full range of approaches for distributing instruction to physically dispersed students.

the nearly 46,000 Army and Navy RC personnel who required training in FY95, in contrast to the approximately 20,000 RC personnel who attended resident training in that year (Section II, Table 3).

- Fiscal savings in travel and per diem (which are relatively easy to estimate), and reductions in time to train, training material costs, instructor costs, and materials preparation and modification costs potentially can be realized from use of DL technologies (Section II.2).
- Increased readiness and workforce productivity obtainable from comprehensive use of DL technologies is difficult to estimate, but it may prove to be the primary payoff from systematic adoption of DL technologies for RC training (Section II.2).

DL Is Little Used by DoD Today

- Investment reported by the Services in DL technologies is limited and the use of these technologies is rare—overall, estimated to be less than 1 percent of Service RC training activity (Section III.E).
- Most Service expenditures for DL are in hardware rather than courseware, a practice that limits the utilization of DL systems (Section III.F).

Converting to DL Requires Sizable Up-Front Investments

- Conversion to DL courseware requires an up-front investment while resident training programs continue; financial payback from reduced travel, per diem, and schoolhouse costs begins as DL comes on line and resident courses are phased out or reduced (Section IV).
- Cost estimates to convert conventional schoolhouse instruction to DL courseware vary widely. Service investment cost estimates for RC DL are sizable, ranging from about $500M to $1,800M. However, eliminating duplication among the 1,097 courses that the Services independently propose to convert to DL would reduce these conversion costs (Section III.2).

The Services Plan to Convert About One in Five Courses to DL

- The Services plan to convert about 19 percent of their courses (1,097 of 5,847) for RC training to DL. Although the Navy plans to convert only 1 percent of its courses (27 of 2,433) for RC training, the Navy already has about 600 DL courses in a print format (Section II).
- While the Navy and Air Force plans indicate 100 percent conversion of all prospective DL courses, the Army plan calls for 100 percent DL conversion of only 7 of 532 courses suitable for conversion (Section II, Table 4). Thus,

most Army RC personnel enrolled in DL courses would still be required to travel to resident training sites.

Joint Management of DL is Needed To Maximize Savings

- Configuration standards are essential to ensure DL interoperability among the Services and among elements within each Service (Section III.D).
- Joint management of DL courseware development is needed to avoid duplication of course material; joint-Service courseware can be used in many cases in which Service courses—whole or in part—are the same or similar to those of another Service (Section III.D).

Data Gaps Preclude Intelligent DL Investment Decisions

- Data furnished by the Services differ widely in quality and comprehensiveness. Despite commendable efforts to respond conscientiously to the DepSecDef tasking, gaps and uncertainties remain in all Service plans for using DL in RC training (Sections II, IV).
- Service budgets provide no budget line items or budget exhibits under which funding for DL can be uniformly identified, tracked, and managed (Section II).
- Service plans do not identify the marginal cost of the schoolhouse infrastructure (instructors, training developers, training equipment, course maintenance, school operations, etc.) or discuss how implementing DL would affect the present schoolhouse infrastructure and costs (Section II).
- Data on opportunities to use DL technologies to train 1.6 million personnel in the ACs and 900,000 DoD civilians, either in residence or at a distance, have not been compiled or studied (Section III.C). Effective strategic plans for RC training cannot be devised without full consideration of Total Force training strategies and plans (Section IV.E). With few exceptions, the content of courses is the same for AC and RC personnel in the same job occupations. Thus, DL Courseware could be used by the Total Force, whose larger population makes the economics of using DL technologies more attractive.

RECOMMENDATIONS

Based on the above findings, senior representatives from the Office of the Secretary of Defense, the Joint Staff, the four Military Services, and other Defense Agencies should:

1. **Examine DL in a Total Force context: all Services, all components, and DoD civilians.** This examination should include schoolhouse infrastructure cost, DL infrastructure cost, travel and per diem costs, costs associated with resident training, a thorough review of the costs of converting

conventional classroom courses to DL technologies, and expected improvement in both training efficiencies and personnel readiness.

2. **Prepare a cohesive, Defense-wide action plan for DL that fully capitalizes on the opportunities provided by DL technologies. If anticipated improvements in training efficiency and personnel readiness warrant, identify milestones that expeditiously move the plan forward for implementation.** This action plan should address the need for developing a DoD organizational structure to assist in:

   - Guiding and assessing the application of DoD DL technologies in a Total Force context that includes ACs, RCs, and the Defense civilian workforce;
   - Ensuring that DoD DL technologies are developed, managed, and used in a cost-effective manner; and
   - Identifying and enforcing configuration standards for DoD DL technologies.

I. INTRODUCTION

A. BACKGROUND

The Services accomplish most of their training of individuals (as compared to training of units)[2] in residential schoolhouse settings. This is true for both active component (AC) and reserve component (RC) training. For several thousands of courses, the Services bear the travel costs and temporary duty (TDY) costs needed to support RC students in centralized training facilities. This practice affects Service operations, unit performance, and quality of life for individuals whose civilian work schedule and family responsibilities are interrupted by travel to distant training locations. These factors have motivated the Services' RCs to look for alternatives to residential training presented in centralized schoolhouses. Currently, the need to identify acceptable alternatives is increasing because: (1) budget pressures are reducing funds to operate centralized schoolhouses; (2) with modernization and technology enhancements that increase the complexity of military equipment and support systems, training demands are increasing; and (3) national strategies have increased dependence on reserve call-up for military operations.

Representatives from the Services and the Office of the Secretary of Defense (OSD) have been meeting quarterly for about 2 years to discuss and promote the adoption of Distance Learning (DL)[3] technologies by the Services. DL involves using available instructional technologies—i.e., print, videotape, computer-based training (CBT), interactive videodisc (IVD)/compact disc (CD), and video teletraining (VTT)—to deliver training to students' homestations and homes. In this sense, DL technology is not limited to any single instructional approach, such as VTT. Some instruction is, of course, not amenable to DL—e.g., initial entry training for new Service personnel, flight training, and

---

2 "Individual training" prepares the soldier, sailor, airman, or marine in the Services' institutional base to perform specified tasks related to his or her assigned duty position. "Unit training" (individual, collective, and joint or combined) takes place outside the Services' institutional base.

3 Distance Learning is structured learning that takes place without the physical presence of an instructor. In this paper, DL is a generic term used to refer to distance learning, distance training, distance education, distributed training, distance instruction, etc. DL technology includes the full range of approaches for distributing instruction to physically dispersed students.

training that primarily concerns psychomotor skills—but many instructional objectives in the Services can be met by DL technologies.

Two joint-Service/OSD review groups have been formed to identify and exchange information concerning Distance Learning technologies:

- The **Total Force Distance Learning Action Team** is concerned with requirements and technological opportunities for DL; coherent and balanced strategies for the adoption of DL and DL technologies by the Services; ensuring cost-effective development, management, and use of DL technologies; identifying standards; and ensuring interoperability.
- The **Guard/Reserve Training and Training Technology Subcommittee** establishes and oversees procedures for exchanging information among the Service RCs and relevant Defense agencies about the effectiveness, costs, and availability of DL technology used for education and training.

Formal tasking from the Deputy Secretary of Defense extended the informal review of DL requirements and technological opportunities by the Total Force DL Action Team and the Guard/Reserve Subcommittee. Program Decision Memorandum (PDM) II of 27 October 1994 tasked the Services to review available DL technologies and to submit plans for using the technologies to train RC personnel (Ref. 1).

Additional guidance for the PDM-directed study was provided in a 2 February 1995 memorandum to the Services from the Assistant Secretary of Defense for Reserve Affairs (Ref. 2). The memorandum requested two groups of data that would facilitate OSD evaluation of the Service plans. One data set concerned measurable advantages in FY95 if all RC resident training for enlisted personnel could hypothetically be delivered to the students at their home stations. The other data set concerned course conversion criteria, multimedia selection, course conversion cost, DL transmit and receive cost, DL infrastructure cost, and schoolhouse infrastructure cost.

B. OBJECTIVE

The objective of this report is to summarize and evaluate Service plans to adopt DL technologies. The evaluation includes consideration of information exchanged in the joint-Service/OSD groups that reviewed training requirements and training technology.

C. METHODOLOGY

We used documented Service plans, briefings, training data, and verbal explanations provided by Service representatives to develop summary statistics for applying DL technologies in RC training. Data from Service plans (Refs. 3, 4, and 5) prepared in response to the DepSecDef tasking are discussed in Section II, Service Plans.[4]

In evaluating the Service plans, we considered knowledge gained during a 2-year informal review of Service training requirements and training technology. That knowledge is described in Section III, Informal Review. Six subsections discuss the following:

- The cost effectiveness of DL in numerous applications.
- The potential payoff of DL in improving individual readiness.
- A notional joint-Service DL system.
- Essential conditions for successful joint-Service DL.
- Current DL applications in DoD.
- Current and future DL funding.

Section II, Service Plans, contains a summary of Service plans to incorporate DL training. This section also includes summary cost data. Section III, Informal Review, is a commentary on the data and summary statistics presented in Section II. Section IV, Discussion, contains an evaluation of the material presented in Section III.

---

4 The Service plans documentation is too large and unwieldy to be included as appendices.

II. SERVICE PLANS

All Services have policies that require non-prior-Service personnel to attend recruit and initial skill training in residence at various schools. The acculturation requirement satisfied by this training is the only general principle stated by the Services for excluding training courses from DL presentation. In their plans, the Services indicated the types of training they propose for conversion to DL for their RCs. As Table 1 shows, Service plans call for DL applications in many types of training.

Table 1. Types of RC Training That Would Be Delivered by DL

Type Training	Army	Navy	Air Force	Marine Corps
Functional[a]		√	√	√
General Military Subjects[b]		√		√
Professional Military Development[c]	√	√	√	√
Reclassification[d]	√	√		√
Skill Progression[e]	√	√	√	√
Special Skills[f]		√	√	√

a Enables personnel to perform military functions, e.g., staff planning.
b For example, amphibious warfare.
c Includes leadership training.
d Initial skill training for prior-Service personnel whose military experience does not qualify them for their RC duty positions.
e Prepares personnel for more advanced jobs in their fields.
f For example, hazardous material handling.

Table 2 shows the percentage of hours of DL media called for by three of the Services. Because the Marine Corps uses other Services' schools to train over half (52 percent) of its military occupational specialties (MOSs), the DL media for Marine training will be some mix of other Service choices. The Marine Corps plans did not indicate DL media distribution for the training it provides with its own resources.

Table 2. Percentage Distribution of Planned RC DL Hours by Type Media

Service[a]	Print	Videotape	Computer-Based Training	Interactive Videodisc/ Compact Disc	Video Tele-training	Other[d]	TOTAL
Army	19	12	27	21	11	10	100
Navy	0[b]	0	70	17	13	0	100
Air Force	56	2	24[c]		18	0	100

a The Marine Corps will leverage other Services' DL since 52 percent of Marine Corps MOSs are trained by the Army, Navy, and Air Force.

b Does not reflect about 600 courses (about 1,800 hours) currently being delivered in print.

c The Air Force treats CBT and IVD as a single media category.

d Includes audio conferencing.

Table 3 shows for each Service the number of courses (Column 2) that could be made available to satisfy FY95 RC requirements for enlisted resident training. It also shows the number of courses (Column 3) that Service plans call for converting, in whole or in part, to DL. The Army would convert 33 percent of its courses to DL—although most would be only partially converted. The Marine Corps would convert 33 percent of its courses to 100 percent DL delivery. The Air Force would convert 29 percent of its courses to 100 percent DL. While the Navy would convert only 1 percent of its resident courses, it already delivers many courses using DL technologies. The most used DL medium is print, which the Navy already uses for about 300 correspondence courses on professional/ technical material and for another approximately 300 correspondence courses on general military subjects. These correspondence courses are prerequisites for promotion examinations for all Navy enlisted personnel (Reserve and Active).

The fourth column in Table 3 shows the number of RC personnel who require training in FY95 and who would receive it from courses that the Service plans identify as being convertible in whole or in part to DL. The fifth column shows the number of RC personnel who would receive training in FY95 if the courses the Services plan to convert were immediately available in DL format. No funds have been budgeted for any of these conversions. There is, therefore, no likelihood that the personnel counted in either the fourth or fifth column will receive DL training. The personnel in the fifth column were scheduled to receive resident training in FY95.

Table 3. FY95 Requirements for Training RC Enlisted Personnel in Resident Courses

Reserve Component	Number of Courses: Total	Number of Courses: Convertible All or In Part to DL[a]	Number of RC Personnel: Requiring Courses That Service Plans Identify as Convertible to Distance Learning[b]	Number of RC Personnel: Who Would Take in FY95 Those Courses That Would be Converted
Army Guard	1,600	532 (33%)	12,606	8,096 (71%)
Army Reserve	1,600	532 (33%)	24,095	10,104 (42%)
Navy Reserve	2,433	27 (1.1%)	9,063	1,347 (15%)
Air National Guard	1,400	402 (29%)	9,311	9,311 (100%)
Air Force Reserve	1,400	402 (29%)	3,225	3,225 (100%)
Marine Reserve	414	136 (33%)	2,120	2,120 (100%)

[a] Funds to convert resident courses are not in Service budgets.

[b] Most Army courses would be partially converted; Army RC personnel in this table require MOS qualification training courses, each of which is at least two-thirds convertible to DL. All Navy, Air Force, and Marine courses would be completely converted to DL.

Under the plans summarized in Table 3, the Navy would completely convert 27 courses and the Air Force would completely convert 402 courses to DL. By contrast, the Army would convert only 7 of 532 courses to 100 percent DL, and only 2 percent (11 courses) would be converted to more than 80 percent DL. Table 4 shows the distribution of the Army DL courses by conversion percentage.

Table 4. Conversion of Army Courses to DL

Percentage of Courses Converted to DL[a]	100	94	80	70	67	50	40	33
Number of Courses	7	4	157	177	43	3	6	135
Percentage of 532 Courses	1	1	30	33	8	1	1	25

[a] Measured in hours of instruction.

A. TRAINING AND READINESS

Table 5 shows the training requirements for Army RC enlisted personnel, who are potentially the heaviest users of DL, both in terms of the number of MOSs covered and the number of MOSs for which there are resident training courses available in FY95. Data from Table 5 and the Army Training Requirements and Resources System (ATRRS) suggest the training and readiness payoff that DL could provide in FY95:

- Resident training courses are available for 65 percent (72,080/110,553) of all Army RC enlisted personnel who are not MOSQ.
- Resident courses that current Army plans call for converting to at least 67 percent DL provide places for only about one-half of the personnel (36,701/72,080) who need them.
- ATRRS data show that FY95 quotas allow attendance by only 67 percent (24,541/36,701) of the RC personnel who need the convertible-to-DL courses.
- ATRRS data indicate that RC attendees in FY94 used only about 75 percent of the quotas for resident course training that were available to them. (Actual RC attendance for FY95 is not yet known.)
- 18,200 RC personnel are therefore expected to attend FY95 resident training ($0.75 \times 24{,}541$).
- 36,701 personnel could be trained using DL (if Army plans were budgeted and carried out) in contrast to the 18,200 (about 50 percent) who instead are likely to receive residential instruction.

The potential improvement in Army RC readiness [twice as many personnel would become MOSQ (MOS qualified)] from having the instructional means to train those who would not otherwise attend resident training is shown in the last two columns of Table 3. When both Army and Navy RCs are considered in Table 3, the courses that their Services plan to convert to DL could potentially provide training to 45,764 RC personnel who require individual training, whereas only 19,547 would attend the resident versions of these courses in FY95. The 26,217 who would not be trained without DL conversions include 18,501 Army RC personnel. The potential gain is thus full MOSQ status for a group equivalent in size to about one-third of the enlisted strength of the Army Guard's Enhanced Readiness Brigades. For the Navy, 9,063 personnel require courses that could be converted to DL, but only 1,347 would attend those courses in residence during FY95. Thus, converting these courses to DL could provide training to 7,716 Naval Reserve (NR) personnel who need it but will not receive it in FY95. On the other hand, converting just 27 Navy courses to DL raises the training readiness level of the 7,716 NR personnel only slightly, from 0.69 to 0.72 in the Navy's system for measuring Overall Training Effectiveness.

Table 5. Number of Army RC Enlisted Personnel Who Are Qualified (Q) or Not Qualified (NQ) in Their Duty MOSs in FY95

Population	Guard		Reserve		Guard + Reserve		
	Q	NQ	Q	NQ	Q	NQ	$\frac{NQ}{Q+NQ}$
All Personnel	251,155	64,349	133,461	46,204	384,616	110,553	.22
Personnel with MOSs for which there are Resident Training Courses in FY95	76,596	30,206	120,653	41,874	197,249	72,080	.27
Personnel with MOSs who could be trained using resident courses that are more than 67 percent converted to DL	28,168	12,606	68,779	24,095	96,947	36,701	.27

B. COSTS

Table 6 shows the number of hours of DL courseware called for in the Service plans. Although not budgeted, the Service efforts would convert a total of 1,097 RC courses—532 Army, 27 Navy, 402 Air Force, and 136 Marine Corps—either wholly or in part to DL. Service estimates of cost per hour (CPH) to convert resident course material to DL courseware vary widely for print ($1,300 to $5,000), videotape ($8,300 to $17,000), VTT ($260 to $19,000), CBT ($4,000 to $14,000), and IVD/CD ($4,000 to $19,000). Costs vary widely due to such factors as the nature of the material being converted; the quality of the existing program of instruction; presence or absence of automated aids for course conversion; tailoring of course content; sequence, pace, and style of instruction to individual needs; amount of interaction in the conversion product; and different mixes of in-house and contracted courseware development.

Table 7 shows that, based on high and low CPH estimates by the Services, the total cost to convert to DL all 1,097 RC courses called for by the Service plans would range from $526M to $1,833M. To the extent that duplication exists among the 1,097 courses that the Services have independently proposed for conversion, an undetermined part of the conversion cost can be avoided.

Table 6. Number of Hours of DL Courseware for the RCs

Distance Learning Media	Number of Hours				
	Army	Navy[a]	Air Force[b]	Marine Corps[c]	All Services
	(532 courses)	(27 courses)	(402 courses)	(136 courses)	(1,097 courses)
Print	15,932	0	8,586	6,477	30,995
Videotape	10,572	0	370	4,091	15,033
Computer-Based Training	22,575	752	3,643	9,204	60,144
Interactive Video Disc/Compact Disc	17,564	184		7,158	
Video Teletraining	9,771	136	2,848	3,750	32,377
Other	8,653	0	0	3,409	12,062
Total Hours Each Service	85,067	1,072	15,447	34,089	135,675

a Aggregated length in hours of Navy RC courses assuming 8-hour days.

b The Air Force uses a single media category for CBT and IVD.

c The Marine Corps will use the resources of other Services for DL training. Total hours for Marine training are distributed among DL media using Army percentages.

Table 7. Cost to Convert All Resident Course Candidates to DL Media for the RCs

	Cost per hour (CPH)[a] (dollars)		Cost to Convert (thousands of dollars)							
			High CPH				Low CPH			
	High	Low	Army	Navy	Air Force	Marine Corps	Army	Navy	Air Force	Marine Corps
Print	5,000	1,300	79,660	0	42,930	32,385	20,712	0	11,162	8,420
Video Tape	17,000	8,300	179,724	0	6,290	69,547	87,748	0	3,071	33,955
Computer-Based Training	14,000	4,000	316,050	10,528	60,110	128,856	90,300	3,008	14,572	36,816
Interactive Video-disc/Compact Disc	19,000	4,000	333,716	3,496		136,002	70,256	736		28,632
Video Teletraining	19,000	260	185,649	2,584	54,112	71,250	2,540	35	740	975
Other[b]	10,000	10,000	86,530	0	0	34,090	86,530	0	0	34,090
Total Cost Each Service			$1,181,000	$16,608	$163,442	$472,130	$358,086	$3,779	$29,545	$134,468
Total Cost All Services			$1,833,180				$525,878			

a CPHs are highs and lows of all Services' estimates, except low CPH for Video Teletraining. $260 is second lowest CPH for VTT; Navy CPH estimate is zero.

b Army submitted an "other media" category, which is principally audio conferencing, and a single CPH estimate.

Table 8 shows current travel and per diem expenditures related to TDY for centralized, resident training for RC personnel. The average expenditures shown are (1) based on historical Service data for FYs 90–94 and (2) converted to FY95 dollars by use of constant dollar multipliers. The resulting data identify estimated FY95 RC travel and per diem costs for centralized, residential training. The Service plans would permit only a portion of these costs to be avoided. However, travel and per diem are not the only savings potentially available from use of DL technology to provide RC training. Savings in time to train, training material costs, instructor costs, instructional material preparation costs, and base operations support will be reduced to an unknown extent by implementing DL courses.

Table 8. Estimated FY95 Costs of Travel and Per Diem for RC Resident Training

Service	Average Cost (millions of dollars)
Army	$32.4
Navy	1.2
Air Force	20.1
Marine Corps	1.7
Total	$55.3

The economic value of increased training accessibility and the resulting increased readiness available from more comprehensive use of DL technologies is difficult to estimate, but could be greater than the training cost savings. It may prove to be the primary payoff from systematic adoption of DL technologies for RC training.

C. FISCAL PLANNING FOR DL

The Service DL plans reveal no budgeting information related to the conversion of resident instruction to DL courseware. Further, the Service plans do not compare the overall costs of resident training versus DL using an economic analysis or business plan model. The great variability in cost estimates, reflected in Table 7, suggests that a rigorous review of costs is needed for making decisions concerning the conversion of courses to DL and the application of DL in RC training.

III. INFORMAL REVIEW

The 2-year joint-Service review of training requirements and training technology has involved exchanges of information on applications of DL to many military and civilian groups in DoD and other federal agencies needing a variety of training courses. This long, informal review considered analyses, pilot tests, and experience—in academia, the commercial sector, and the military—which demonstrate that DL can provide quality training opportunities at reduced cost. The substance of this DL review is summarized in the following sections: Cost Effectiveness, Training and Readiness, DoD Distance Learning System, Joint-Service Imperatives, Distance Learning in DoD Today, and Funding for Distance Learning.

A. COST EFFECTIVENESS

In the late 1980's, the U.S. Army Training and Doctrine Command (TRADOC) undertook an extensive study of future Army training (Refs. 6 and 7). For 305 courses that were recommended for full or partial DL, the cost benefit over an assumed payback period of 7 years was $1.52 billion in FY90 dollars. This payback represents potential net savings resulting from subtracting the costs of course conversion and DL infrastructure from the costs associated with formal resident instruction for the same courses in TRADOC schools, academies, and centers. The TRADOC study concluded that a DL program would "provide requisite training at a lower cost while maintaining training readiness" (p. 5-1, Ref. 7).

The Air National Guard (ANG) Professional Military Education Center (PMEC) is partially converting to DL a 6-week resident program required for all NCOs in its ANG NCO Academy Program (Ref. 8). When converted and validated, the same program could be delivered with only 2 weeks in residence and DL for the remainder of the course work. Comparative test scores indicate the resident-DL students are as successful as the all-resident students. By reducing residency from 6 weeks to 2 weeks, the resident/DL course will be able to save 4 weeks of per diem cost; will be able to reach 3,000 students per year; and will be able to solve a major problem for Air Force RC NCOs, who find it difficult to leave their civilian jobs for 6 weeks.

The NCO Academy Program is a prerequisite for promotion. The ANG reports an eligible population of 47,000 personnel—too many to be accommodated by resident-only instruction—waiting to attend the NCO Academy. Total Air Force requirements would add thousands more potential students. This resident/DL course is currently under development and has not been formally integrated into the ANG PMEC program. Full implementation would require additional staffing and instructor resources. Table 9 shows a cost comparison and potential savings (in constant dollars) from this partial conversion of the NCO Academy Program to DL.

The appendices summarize reviews of *over 300 studies* that evaluated the effectiveness, in terms of student achievement, training cost, and reduction in student training time, of various DL technologies compared to conventional instruction.

1. Computer-Assisted Instruction (CAI)

Orlansky and String (Ref. 9, and see Appendix A) found that (1) student achievement with CAI and computer-managed instruction (CMI) courses in military training schools was the same or greater than with conventional instruction, and (2) CAI and CMI saved about 30 percent of the time (median value) needed by students to complete the same courses given by conventional instruction. The findings are the result of 48 comparisons of CAI/CMI and conventional instruction in 30 different studies.

2. Interactive Videodisc (IVD)

In 47 comparisons of IVD and conventional instruction in various settings—namely, military training, industrial training, and higher education—Fletcher (Ref. 10, and see Appendix B) found that IVD increased achievement for the average student (50th percentile) to the 69th percentile. The average amount of time saved by students using IVD in all these comparisons was 31 percent.

3. Computer-Based Instruction (CBI)

Redding and Fletcher (Ref. 11, and see Appendix C) presented results from numerous studies of CBI showing the following increases in percentile achievement for the average student in three instructional settings: 65th percentile in 42 studies of secondary school students; 60th percentile in 101 studies of college students; 66th percentile in 24 studies of adult education students.

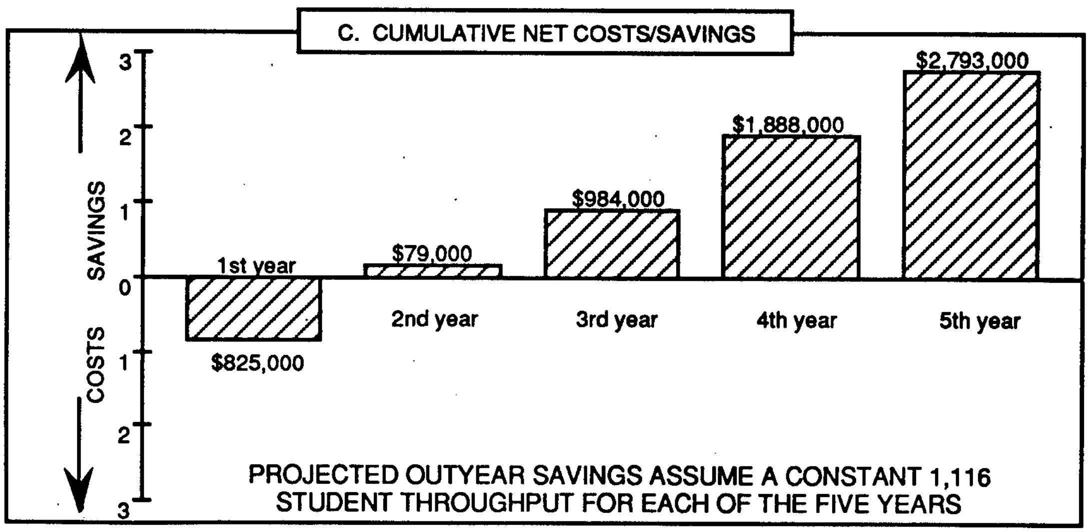
Table 9. Comparison of Air National Guard NCO Academy Program Delivered in 6 Weeks in Residence or by DL at Homestations Followed by 2 Weeks in Residence (Source: Ref. 8)

A. BACKGROUND DATA

- DL involves thirty-seven 3-hour VTT sessions; DL + 2 weeks in residence includes same course content as 6 weeks in residence.
- VTT network includes 93 DL site facilities (homestations) with 12 students per site (total of 1,116 students).
- VTT equipment: 1-way video, 2-way audio acquired by purchase based on one channel uplink.
- Each student gets $29 for each 3-hour DL session and $1,060 for 2 weeks in residence; each student gets $3,532 for 6 weeks in residence.
- Travel cost to resident training facility: $392.
- Facilitators monitor DL site training and provide pinch-hit instruction in case of VTT failure; 2 facilitators are trained for each DL site.
- Facilitator training cost is $1,205 each; facilitator pay per 3-hour DL session is $35.

B. FIRST YEAR COSTS (thousands of dollars)

Expense Item	6-Week Residence	DL Plus 2-Week Residence
EQUIPMENT		
Compressed Digital Video (nonrecurring)–1V, 2A*		$1,730
Communications (recurring)		85
Operation and Maintenance (recurring)		154
STUDENTS		
Pay for DL phase		1,197
Pay for Resident phase	$3,941	1,182
Travel	437	437
FACILITATORS		
Pay while in training		224
Pay for DL sessions		120
Travel		73
Totals	$4,378	$5,202



* 1-way video, 2-way audio

Redding and Fletcher also describe in Appendix C a report of about 250 primary studies that provide quantified measures of student achievement in several instructional settings—namely, elementary school, secondary school, college, Japanese schools, and special education. Overall in these studies, CBI raised the percentile achievement of the average student to the 66th percentile. The report also covered about 100 CAI-versus-conventional instruction studies that did not use quantified measures of student achievement; these studies do conclude, however, that CAI enables students to learn as much in less time.

4. Computer-Based Training (CBT)

Johnston and Fletcher (Appendix D) reviewed 33 empirical studies that compared CBT with conventional instruction in military training (Ref. 12). Thirteen of the 33 comparisons are included in the 48 comparisons considered in Appendix A. However, although student achievement was not quantified in the Appendix A comparisons of CAI/CMI and conventional instruction, all 33 comparisons in the Johnston-Fletcher review use percentile achievement to measure the effectiveness of instruction. Johnston and Fletcher found in the 33 comparisons that CBT raised the average student's achievement to the 67th percentile. In a subset of 23 comparisons (11 of which appear in Appendix A) that measured instruction time, average time savings from using CBT was 30 percent; that result is consistent with average time saving reported in Appendix A.

5. Video Teletraining (VTT)

The commercial world and academia increasingly use VTT to reduce travel, per diem, and instructional delivery costs. Several studies that are summarized in Appendix E indicate that VTT can be at least as effective as residential training in military applications and that it could be less costly as well.

Table 10 lists subjects of military courses—varying in length from a few days to several weeks—in which student achievement improved or course time decreased or both—when advanced training technologies replaced conventional instruction.

Table 10. Student Achievement Improved and/or Course Time Decreased When Advanced Training Technologies Replaced Conventional Instruction for the Following Subjects

Computer-Assisted Instruction	
Basic Electronics	Medical Assistant
Electricity	Vehicle Repair
Machinist	Weather
Training Materials Development	Tactical Coordinator (S-3A)
Recipe Conversion	Fire Control Technician
Aircraft Panel Operation	
Computer-Managed Instruction	
Aviation Familiarization	Materiel Facilities
Aviation Mechanical Fundamentals	Precision Measuring Equipment
Inventory Management	Weapons Mechanic
Computer-Based Training	
Basic Reading Skills	Interpersonal Skills
Copilot Integrated Control System	Machinist Course
Medical	Personnel Administration
Vehicle Repair (cooling system, warning system, clutch, brakes)	Crew-Served Weapons
Troubleshooting Logic Circuits	Console Operation
Electronic Principles	Foreign Language
Air Traffic Control—Weather Fundamentals	Operation and Maintenance 6883 Test Station
Fuel Savings Advisory System	Typing
Basic Electronics	Oscilloscope Operation
Recipe Conversion	Electronic Technician
Keyboard	Tactical Coordinator
Developmental Tactical Operations System	Acoustic Analysis
Troubleshooting M1A1 Fuel Supply System	Reading Skills
Interactive Videodisc	
Interpersonal Skills	Foreign Language (Beginning Spanish)
Helicopter Maintenance (hydraulics)	Physics "Puzzle of the Tacoma Bridge Collapse"
CPR Recertification Training for Registered Nurses	Biology (Respiration)
Communication Circuit Maintenance	Biology (Climate and Life)
Handling of Hazardous Materials	Chemistry (Kinetics and Equilibrium)
Equipment Operation (16-mm projector)	Chemistry (Gas Analysis)
Biology "Development of Living Things"	Medical Education (Trauma)
Foreign Language (Beginning French)	Public Health (CPR Instruction)
Video Teletraining	
Maintenance Record-Keeping	Army Command and General Staff College Courses
Safety	Logistics Management
Divisional Chief Petty Officer Indoctrination	
Common Leadership Training	

B. TRAINING AND READINESS

Among other activities, the Total Force DL Action Team and the Guard/Reserve Subcommittee reviewed individual training and readiness in the Army Guard and the Army Reserve. The following statistics pertain to 190,000 Army RC enlisted personnel in 81 military occupational specialties for combat support and combat service support (Ref. 13):

- 63 percent of Total Army personnel belong to the RCs.
- 39 percent of the RC personnel were not MOSQ for their duty positions; 4 percent of counterpart personnel in the Army AC were not MOSQ.[5]
- Only 41 percent of the Army RC personnel who were not MOSQ were slated to attend resident training in FY95. Lack of funding is the principal reason for not sending 59 percent of non-MOSQ RC students to resident training.

Army RC units use mentors, who are diverted from their normal duties, to provide whatever training can be given locally to the 59 percent of RC personnel who are not MOSQ and not scheduled for resident training. The availability of DL would (1) enable a significant portion of the RC personnel who cannot go to resident courses to obtain some MOSQ training and (2) save the travel and per diem expenses of sending 41 percent of RC personnel away for training.

For a readiness perspective on MOSQ percentages, consider different military operations involving call-up of Reserves. For small or moderately sized operations, such as Haiti, there are a couple of options for mobilizing a well-trained and ready Reserve contingent even if large parts of the RCs are not MOSQ. First, only units stocked with MOSQ personnel would be selected for call-up. Second, derivative subunits created from larger units can be combined with individual transfers to form new units heavy in MOSQ personnel.

For a large operation, such as the Gulf War, where the Reserve call-up is also large, having a high percentage of RC personnel who are not MOSQ is a liability and could jeopardize the operational mission. Loading up a few units with MOSQ personnel and shuffling subunits and individuals to form new units are not useful options when training deficiencies are widespread and mobilization time is short.

---

5 To become MOSQ, a soldier must demonstrate in a formal course of instruction proficiency in individual skills and an ability to do his or her job.

C. DoD DL SYSTEM

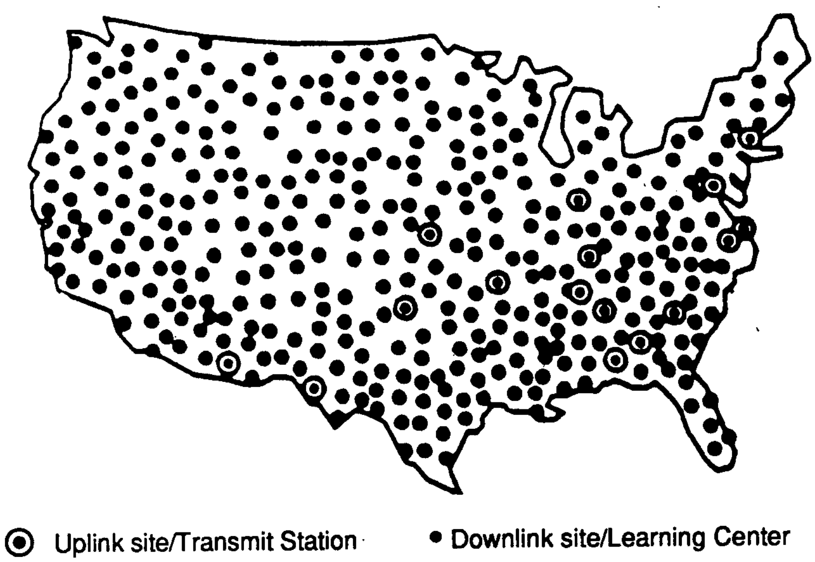
A concept for a DL system was formulated in the meetings of the Total Force DL Action Team and the Guard/Reserve Subcommittee. This concept for a joint-Service approach to the evolution of DL, including the ACs with their 1.6 million personnel, is shown in Figure 1. This Total Force DL plan could include DL for 900,000 DoD civilians, about half of whom receive about 50 hours of training annually at a cost of about $125M for travel and per diem. A Total Force DL Plan could also provide the means for an interface with VTT networks of other Federal agencies for mutual advantage and savings.

D. JOINT-SERVICE IMPERATIVES

Early in the joint-Service review, it was recognized that (1) configuration standards were required to ensure DL interoperability among the Services, and (2) economies in courseware development must be sought for DL courseware useful to more than one Service. The configuration standards issue has three dimensions: media selection, technical performance, and economics.

- Media selection: Services must adopt the same media, i.e., print, videotape, computer-based training, interactive videodisc/compact disc, and video teletraining, for a common course or common segment of a course. This requirement would not preclude joint-Service adoption of more than one medium to fit different situations among the target populations to be trained. For example, VTT might be used to deliver training to DL centers, while the same instructional material contained on CD can be used at overseas bases, on ships at sea, or with personal computers in the home.
- Technical performance: Baseline technical performance criteria—e.g., frame rate for video imagery and transmission rate for VTT networks, and MIL-STD-1379D for interactive courseware (ICW) (Ref. 14)—must be used by all Services.
- Economics: A Service's choice of DL system architecture and communication network should not penalize the other Services with needless costs. Fielding DL courseware products or services involving closed system architectures defeats the ability to leverage resources by effectively denying access to those outside the system.

Figure 1. DoD Distance Learning Network (notional)
(Source: Army Training Support Center Briefing)



- Existing Facilities: Military bases, Reserve centers, and Guard armories will be the DL Centers (site dots on map do not represent actual facilities).
- Media Available: VT, VTT, CBT, IVD/CD equipment developed to common standards.
- Users: All components of all Services; some sharing of DL Centers between active and reserve components and among Services will occur.
- Training Focus: Cognitive skill training at the DL Centers; psychomotor skill training will be done during monthly inactive duty training and annual active duty training periods.
- Numerous DL Centers: Enough that most Service personnel live within 50 miles of one so that travel and per diem costs would be avoided. Students with computer and visual information equipment could get stay-at-home training.
- Student Support Groups: Formal or informal peer groups could be formed for DL courses as they are for conventional schoolhouse courses to facilitate learning.

Training courses for many occupations common among the Services (e.g., electrician, truck mechanic, aircraft maintenance, medical personnel, food service, ordnance handling, motor transport operator) have essentially the same instructional content, regardless of the Service. Duplication of joint-Service courseware, the development of which is very expensive, must be avoided.

E. DISTANCE LEARNING IN DoD TODAY

Interactive media applications—i.e., CBT, IVD, and CD—are rarely used in Defense training. They represent a mature technological opportunity that is seldom used. These media have been shown by empirical evidence from numerous applications of interactive courseware to *reduce training time by about 30 percent* (see Sections III.A.1, 4), and to *improve average student percentile achievement from 50 to 60 or more* (see Sections III.A.2, 3, 4).

The Services use a mix of in-house resources and contractor support to develop DL courseware. The selection of DL media is based on familiar training models, instructional designs, and network architectures. Although there is no formal tracking of media utilization, no Service representative estimated that more than 1 percent of DoD individual training is currently being delivered by DL technologies.

The introduction of VTT within the DoD grew largely from pilot programs directed by the Army. Funds for VTT from various defense appropriations have been directed primarily at Army Reserve and Army National Guard (ARNG) training. Data collected from these pilot programs and technology demonstrations were later used by the Navy and Air Force to develop their own implementations of VTT. The Navy designed its VTT network to extend school and resident training capabilities, but CESN [CNET (Chief of Naval Education and Training) Electronic Schoolhouse Network] sites have not been established solely for NR training. The Air Force designed and implemented three VTT networks to serve the Active, Reserve, and Guard components of the Air Force, each using its own funds and needs assessment. Thus, these three Services have three different focuses for VTT applications: Air Force AC and RC, Navy AC, and Army RC. The Army's RC focus for VTT applications continues through congressionally directed studies and pilot programs that target the ARNG as a VTT testbed. Based on full VTT implementation by the other Services, there is no technological or operational requirement for the Army to continue to field VTT systems as pilot programs or testbeds.

Within the DoD, the Services operate six separately managed VTT networks. Each network has the means to send and receive DL courseware using internal network resources. Defense Agencies, on the other hand, are establishing networks to "piggy-back" Services' networks or obtain DL programming from sources outside DoD. DoD networks do not employ a single distribution architecture, but with the proper use of gate-ways there is no compelling reason to do so, either to share DL materials or to achieve economies of scale. Table 11 identifies the six VTT networks used by the Services.

Table 11. DoD Video Teletraining Networks

Network	Video, Audio Capability
Chief of Naval Education and Training (CNET) Electronic Schoolhouse Network (CESN)	2V, 2A[a]
Satellite Education Network (SEN)—Army	1V, 2A[b]
Training Network (TNET)—Army	2V, 2A
Air Technology Network (ATN)—Air Force	1V, 2A
Air Force Reserve Network (TNET-Based)	2V, 2A
Warrior Network—Air National Guard	1V, 2A

[a] 2-way video, 2-way audio.

[b] 1-way video, 2-way audio.

VTT networks may model commercial broadcasting (1-way video) or video teleconferencing (VTC) (2-way video). There are significant differences in what the technologies can do, given the realities of a distributed classroom environment. In order to achieve meaningful interactivity with remote sites the number of locations that can be accommodated in a single session must be limited. For example, while it may be technically possible to reach over 100 remote locations using 1-way video (1V) with 30 students at each site, it is not reasonable to expect any meaningful instructional dialogue from such an extensive network. Far fewer sites are typically involved in a 2-way video (2V) VTT session. Based on industry data, about 50 percent of all VTC events involve only two sites, and events with four sites or less account for 85 percent of all VTC. Unfortunately, network sponsors are prone to emphasize the technological "reach" of the system, when the focus might be better placed on quality of the DL instruction provided, accessibility by students, and student throughput.

Table 12 shows the number of DoD VTT 2V, 2A sites. Although the classroom hardware systems for these networks is similar, the Army's TNET is a satellite-based network whereas the Navy's CESN uses terrestrial FTS2000 and Integrated Services Digital Network (ISDN) circuits, both capable of transmitting at 384 Kbps. Differences in audio systems preclude direct interoperability from a TNET site to a CESN site. However, the CESN network hub at Dam Neck, Virginia, is able to operate as a gateway between the two networks.

Table 12. Two-way Video, Two-way Audio (2V, 2A) VTT Networks: Numbers of DoD Sites[a] (Source: Network Managers)

Network	Sites	
	FY95	Projected
Navy CESN	13	25[b]
Air Force Reserve TNET	47	47
Army Training Support Center TNET	68	68
TOTAL	129	144

[a] Each site has transmit and receive capability.

[b] Does not include shipboard.

Table 13 shows current and projected numbers of VTT downlink sites using 1V, 2A networks that belong to DoD and other federal agencies. The DoD networks have been acquired through contracts issued through the Defense Information Systems Agency (DISA). Federal agencies, including DoD, can obtain similar equipment and services from GSA's FTS2000 contract. Both contracts offer parallel systems and services.

Downlinks are shown in Table 13 without differentiating between analog and digital signal reception capabilities. Analog C-band and Ku-band broadcasts require a larger bandwidth to transmit signals than for compressed digital video (CDV) broadcasts. Ten CDV channels can be simultaneously broadcast within the same Ku-bandwidth required for a single analog channel. The resulting cost economies and scarce C-band satellite transponder availability are prompting network managers to look at uplinking VTT digitally. Receive-only dishes can be configured to accept either transmssion mode.

Table 13. One-way Video, Two-way Audio (1V, 2A) VTT Networks: Numbers of Uplinks and Downlinks[a]

Networks, Uplinks	Downlinks	
	FY95	Projected
DoD		
Air National Guard Warrior Network, 3 uplinks	93	240
Air Force Reserve	0	5
Air Technology Network (ATN), 3 uplinks	72	72
Army National Guard, no uplink[b]	0	30
Defense Information Systems Agency, no uplink[c]	22	22
Army Satellite Education Network (SEN), multiple uplinks[d]	83	83
TOTAL	280	452
Federal Agencies		
Department of Energy, 1 uplink	10	20
Environmental Protection Agency	70	70
Federal Aviation Administration, 1 uplink	38	392
Veterans Benefits Administration	0	60
Internal Revenue Service	78	272
United States Postal Service, 4 uplinks, 4 channels[e]	300	350
United States Coast Guard	0	20
Social Security Administration	300	331

a Source: AT&T TRIDOM. All 1-way video, 2-way audio, and subject to change.

b Based on a proposed plan to access SEN and ANG Warrior network.

c Installed with optional NTU equipment to access fee-for-service courseware.

d SEN is the only DoD "gateway" capable of receiving and retransmitting C-band, Ku-band, and CDV.

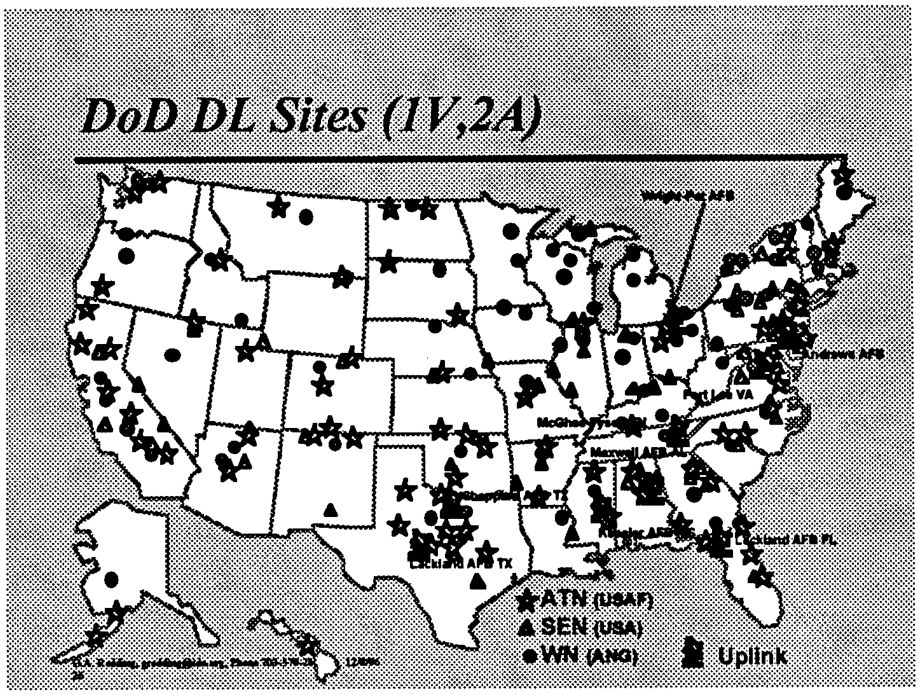
e C-band and Ku-band.

Figure 2 shows a U.S. map with actual locations of uplink and downlink sites of three 1V, 2A DoD VTT networks: Air Force's Air Technology Network (ATN); the Army's Satellite Education Network (SEN); and Air National Guard's Warrior Network (WN). Other fee-for-service educational networks that can be accessed by DoD's 1V, 2A locations using compressed digital video (CDV) systems are identified below:

- National Technological University (NTU): delivers 25,000 programs annually from 46 universities; delivers 13 MS degree curricula and over 1,000 graduate courses.
- Public Broadcasting System Adult Learning Service: provides access to 2,000 colleges and universities.
- Satellite Education Resource Center: includes 500 schools in 28 states.

- Satellite Education Offices: includes offices in Florida, Georgia, Louisiana, and South Carolina.

Figure 2. Locations of Uplink and Downlink Sites of Three DoD VTT Networks[a]



[a] Source: Air Force Institute of Technology Center for Distance Education. The DoD does not maintain a consolidated database of VTT sites.

The economics of VTT networks for existing and planned applications illustrates the need for DL configuration standards. As shown in Table 9, the acquisition of a CDV 1V, 2A VTT network architecture by the Air National Guard (ANG) provides affordable scalability for the DL phase of its NCO Academy Program. The ANG's WN with its basic CDV architecture can be scaled to any number of receive sites. On the other hand, the 2V, 2A architecture of CESN and TNET would present technological problems in concurrently reaching 93 ANG sites for common training. In their basic configurations, CESN and TNET are constrained by technical limitations to 22 and 15 sites, respectively, without additional hubs. However, additional multipoint control units can be "cascaded" to extend the number of participating sites. Table 14 shows the cumulative 5-year life cycle cost if CESN and TNET network architectures were leased and used to reach 93 sites for the NCO Academy Program.

Table 14. Cumulative Life Cycle Costs (in millions of U.S. dollars) of DoD VTT Networks with 93 Sites (Source: Ref. 15)

Network	Lease (L) or Purchase (P)	Year				
		1	2	3	4	5
CESN–2V, 2A	L	6.234	12.467	18.701	24.934	31.168
TNET–2V, 2A	L	9.368	17.421	25.474	33.527	41.580
CDV–1V, 2A	P	3.002	4.083	5.164	6.245	7.325

The costs in Table 14 are driven by a requirement to deliver instructional material to many students (1,116) at many sites (93). As Table 15 shows, if the NCO Academy Program were delivered to only 15 sites (with 12 students each), the advantage of purchasing 1V, 2A VTT equipment over leasing 2V, 2A equipment is much less marked. (The table also shows that CESN has lower life-cycle costs than TNET, as it did in the 93-site case). While a 2V, 2A system is needed for VTC, 1V, 2A networks are generally the cost-effective choices for training, because the two-way audio satisfies nearly all training needs for student-instructor interaction. Moreover, 1V, 2A VTT systems are less costly to expand to deliver training to additional sites (scalability). However, when the Navy uses VTT for the NR, it typically delivers courses to a few students at a few sites and finds its leased 2V, 2A system to be less costly than purchasing 1V, 2A equipment. Thus, both current training requirements and scalability are important considerations in selecting a VTT network. Decisions to lease or purchase VTT hardware (all VTT network *circuits* are leased) are based on several considerations: the cost of equipment and software upgrades, the cost of maintaining the facilities, the type of funding available, and the ability to adequately staff and manage a network operation.

Table 15. Cumulative Life Cycle Costs (in millions of U.S. dollars) of DoD VTT Networks with 15 Sites

Network	Lease (L) or Purchase (P)	Year				
		1	2	3	4	5
CESN–2V, 2A	L	1.043	2.085	3.128	4.171	5.213
TNET–2V, 2A	L	1.495	2.840	4.335	5.830	7.325
CDV–1V, 2A	P	1.049	1.418	1.787	2.155	2.524

Joint-Service use of a VTT network could involve changes in equipment and/or software to accommodate training requirements beyond those of the network owner-

operator. If modifying an established network is the least costly alternative to satisfy other Services' requirements, it seems reasonable that the cost of network modification be charged to the new user-Services. For example, the Navy plan has the 2V, 2A CESN network using smaller bandwidth circuits and desktop (as opposed to classroom) systems for 197 NR sites. As a consequence, the CESN transmission rate of 384 Kbps would be reduced to 128 Kbps for NR training. While some audio and motion video quality is sacrificed, the Navy believes the quality is suitable for its NR training requirements. A draft DoD instruction on VTT networks has identified 384 Kbps, full common intermediate format (CIF), as the minimum acceptable transmission speed for DoD DL networks. If Services elect to use less than 384 Kbps for internal training requirements, they would logically be expected to incur the cost of upgrading to 384 Kbps when participating in joint-Service-user DL. The point is that joint-Service-user business decisions on system architecture and communication networks are necessary to achieve DL interoperability among the Services.

F. FUNDING FOR DL

Assessing the investment in DL against a potential payback defies a single solution. Each Service has developed its own criteria for funding DL, but few initiatives have been preceded by formal needs assessment or requirements analyses. Early work by the Army in pilot VTT studies dealt mostly with the feasibility of the technology and did not examine life cycle management. None of the Defense Agencies or Services are obligated to submit Program Objective Memorandum (POM) actions to support DL programs. One reason is that funding for DL programs has been "taken out-of-hide" by the training communities as they strive to avoid the costs of resident instruction. While this may be acceptable for low-tech DL technologies such as publishing courseware on compact disc-read-only memory (CD-ROM) or establishing "chat" lines on the Internet, more stringent criteria are appropriate for multi-million dollar capital investment or lease programs.

DoD does not have a budget line item or budget exhibit under which funding for DL can be identified; thus, there is no formal mechanism to tally the investments made in any particular DL media. Also, it is easier to identify hardware and circuit costs, since those are provided by third parties, whereas courseware development and conversion may be accomplished using internal resources which are harder to identify. Installed networks have been acquired by a combination of leased services and outright purchases. Systems have been acquired in ways devised to match available funding—either Operations & Maintenance or Other Procurement.

The Services have the responsibility of ultimately directing money to DL programs. For the most part, the Services deserve credit for installing VTT networks out of the limited funds available. However, the application of appropriated funds to DL is inconsistent. As an example, $17M was congressionally mandated for Army VTT in FY94. The Army used $13M to cover other Army priorities. Of the remaining $4M, the Army spent 5 percent ($200,000) on courseware development, 25 percent ($1M) on sustaining VTT overhead, and 70 percent ($2.8M) on leasing VTT hardware and circuits. Effectively, only the money spent on the courseware development contributed to establishing the academic infrastructure. This incident is not isolated. In FY95, $7.5M was appropriated to establish a regional demonstration VTT network for the ARNG (Ref. 16). Several constituencies have emerged, each claiming a share of this appropriation. Legislative sponsors want funds to be directed toward purchasing a few electronic classrooms, outfitting approximately 30, and eventually leasing the aforementioned to local community interests. Of the sum appropriated, currently less than 10 percent will be allocated to developing courseware needed by the ARNG to meet readiness requirements. The remaining 90 percent has been identified to fund engineering services, equipment lease/purchase acquisitions, and to maintain a nonexistent network infrastructure. By not funding concurrent courseware development, the VTT systems in both cases will be severely underutilized.

IV. DISCUSSION

Evaluation of Service DL plans has generated these concerns: (1) too little use of interactive media; (2) not enough conversion to DL; (3) selection of specific VTT technologies with insufficient review of requirements; (4) uncertain cost estimates of converting conventional schoolhouse courses to DL courseware; and (5) unknown costs and benefits of DL in a Total Force context. We discuss these concerns in turn below.

A. INTERACTIVE MEDIA

The Army and the Air Force plan to use CBT and IVD (or CD) for 48 percent and 24 percent, respectively, of DL hours for their RCs. The Navy plan would use these interactive media for 87 percent of the DL hours it proposes for RC training. However, the 87 percent figure is misleading. While the Army and the Air Force plans would use interactive media for over 40,000 DL hours and 3,600 DL hours, respectively, the Navy's plan includes less than 1,000 hours of interactive media for its RC (see Table 6). This is puzzling since empirical evidence—much of it from military test applications—suggests that interactive media are well suited for delivering complex, technical instruction. The evidence shows better training effectiveness (20 or more percent) and faster learning (30 percent) when conventional resident courses are replaced by interactive courses.

B. DL CONVERSION

The Army plans to convert only 11 of 532 courses to more than 80 percent DL, and only 7 of those 532 to 100 percent DL. Thus, even with a DL system in place, travel by RC students to the resident training schoolhouse still would be required for 525 courses. If DL could be substituted for course segments that the Army currently teaches in residence, the travel and per diem savings would be substantial, using the ARNG planning figure of $800 per student for travel cost for resident training. In FY94, about 75,000 enlisted personnel in the Army RCs attended resident training courses. If one-half to two-thirds of the 75,000 students were able to take DL courses, which deliver cognitive training equivalent to that delivered in the schoolhouse, the travel savings in FY94 would have been between $30M and $40M.

Many DL technologies simulate experience with real equipment through the use of video displays or similar means. Two-dimensional (2D) representations of systems or components can be transmitted by DL technologies [which can also present three-dimensional (3D) perspectives of these items] to support "almost hands-on" training that, in many applications, is as effective as 3D hands-on training—and less costly. Systematic evaluations of 3D and 2D maintenance simulators have found few differences in test performance of students who were trained on real equipment and students trained on simulated equipment.

It is also notable that medical schools use synthetic models of hearts, eyes, and brains to provide surgeons the psychomotor training and practice required to work on these and other human organs. If such mock-ups are effective for hands-on training of those who repair the human anatomy, the Services may find equal effectiveness—and cost savings—by developing and distributing to DL centers 3D models to train military personnel to repair weapons, vehicles, and other equipment.

The professional development and leadership courses for the Army RCs are also good prospects for 100 percent conversion to DL media. A reason often cited for having some part of a course delivered in residence is the occurrence of formal or informal teaming that facilitates learning as students help each other. Such facilitation might be achieved by teaming students in the same course at a DL center. If the students in a DL class are not collocated, they can be provided with class rosters, personnel vitae, telephone numbers, and e-mail addresses to facilitate their interactions. Student custody of DoD-owned personal computers and modems for use at home during DL courses is a possible arrangement for Internet communications.

C. VTT NETWORKS

The Navy's choice of a 2V, 2A network for CESN has proven workable for a wide range of Navy courses at select locations, especially since CESN is involved in courseware as well as network operations and can therefore document usage. However, in pursuing its 2V, 2A architecture, the NR has advanced a VTT DL plan that cannot effectively leverage CESN's education and training resources infrastructure. At approximately $75,000 per site per year for CESN, funding is a major consideration. At that cost, installing 197 DL locations would be impracticable for the NR. The NR has proposed an outyear $5–$7M investment in a desktop video teleconferencing equipment suite using a reduced circuit capacity. While the circuits can connect with CESN, data transmission rate would default

to the NR's lowest circuit speed and thereby compromise the quality of instruction for all sites involved in the DL session.

The Army's choice of a 2V, 2A network for TNET relies on a more restrictive communications architecture than the Navy's CESN. Although both use the same basic hardware in the classroom, TNET is more expensive to lease. TNET is intended to deliver only hardware and communications services to trainers and users. Unlike CESN, TNET does not manage the courseware component of this DL application. The ARNG is exploring a scaled-down 2V, 2A VTT application using commercial VTC equipment. As proposed, this application would not function with the existing TNET or CESN networks.

The Air Force Reserve (AFRES) leases 47 TNET sites and obtains network management services from the Army. It is now possible to interconnect the AFRES sites with the ATN and Warrior Networks, by defaulting their 2V, 2A architecture to a 1V, 2A medium. The default to 1V, 2A undermines the TNET contention that all sites must have the ability to transmit video.

Each RC that plans to use or is using a 2V, 2A network defends its choice by citing the ability of 2V, 2A to conduct VTC. Identifying VTC applications serves to undermine the business case for VTT unless VTC users are contributing resources (funds, personnel, equipment). Classroom space can be used as conference rooms, and vice versa, but they are less effective when not used as configured. Only CESN can (historically) defend its VTC dual-use position by being able to offset costs against the DL mission alone. Draft DoD policy does not state a preference (one- or two-way) VTT but does stress the value of interoperability with other architectures and of the ability to gateway among networks.

D. CONVERSION COST

The range of estimates of costs—$526M to $1,833M—to convert conventional schoolhouse courses to DL is very wide. But even the low-end cost is a formidable obstacle to implementing DL for the RCs alone. This is a major undertaking that will require several years to implement.

E. COST-BENEFIT ANALYSIS

Adoption of DL for the Service RCs requires a large investment in course conversion. Conversion requires an investment up front while resident training programs continue; payback in the form of travel and per diem cost savings begins as DL comes on line and replaces resident courses. Such an investment is difficult to defend without

considering the costs and benefits of applying DL to the Total Force. The demonstrated effectiveness of DL should provide advantages to the ACs as well as to the RCs. Therefore, the Services cannot be expected to make adequate fiscal plans for DL until costs and benefits in a Total Force context are evaluated. A number of issues should be resolved: Which courses, of those already identified for conversion to DL for the RCs, would be useful to the ACs? What additional course conversions would be needed? How much would that cost? What effect would inclusion of AC users have on the cost of DL networks?

Potential gains for the Services in training effectiveness should be determined by trading off AC resident training for DL. Other benefits, some of which are not easy to quantify without examining DL in a Total Force context, are the following:

- DL will save travel and per diem costs for resident training. Travel and per diem for the Total Force will exceed by an unknown amount the $55M per year for the RCs alone.
- The conversion of more resident courses to 100 percent DL will save additional RC travel funds.
- Interactive courseware is often more effective and more efficient than conventional classroom instruction.
- Adoption of DL should permit a planned reduction of the infrastructure that supports only resident training.
- There will be a reduction in course conversion costs by eliminating as yet unidentified duplications among courses that the Services nominated for conversion.
- Configuration standards and joint-Service courseware will avoid duplications that exist today in the Services' resident training curricula.
- Development of joint-Service courseware and the shared usage and cost of DL networks for both the ACs and RCs should stimulate each Service to pay for only what is necessary.

V. FINDINGS

The following findings are derived from (1) evaluation of Service plans for using DL technologies to train RC personnel and (2) the continuing informal review of Service training requirements and training technology.

A. POTENTIAL OF DL

- The efficacy of DL technologies, which enable learning to take place without an instructor being physically present, has been demonstrated in the military, academia, and the commercial world by more than 300 studies. DL is as effective as conventional resident instruction in achieving a wide range of instructional objectives (Section III.A and the Appendices).
- Many cost-effective applications of DL technologies—i.e., computer-based training, interactive videodisc training, compact disc training, and video teletraining—have involved AC personnel and DoD civilians in schoolhouse courses (Section III.A). Thus, besides delivering DL to the RCs, these technologies could be used to train AC personnel and DoD civilians either at a distance or in residence.
- DL can be used to train those who, for whatever reason—usually a lack of funds—are unable to travel to resident training sites. DL could have trained the nearly 46,000 Army and Navy RC personnel who required training in FY95, in contrast to the approximately 20,000 RC personnel who were expected to receive resident training in that year (Section II, Table 3).
- Fiscal savings in travel and per diem (which are relatively easy to estimate), and reductions in time to train, training material costs, instructor costs, and materials preparation and modification costs are potentially available from use of DL technologies (Section II.B).
- Increased readiness obtainable from comprehensive use of DL technologies is difficult to estimate, but it may prove to be the primary payoff from systematic adoption of DL technologies for RC training (Section II.B).

B. DL IN DoD TODAY

- Investment reported by the Services in DL technologies is limited and their use is rare—overall use is estimated to be less than 1 percent of Service RC training activity (Section III.E).
- Most Service expenditures for DL are in hardware rather than courseware, a practice that limits the utilization of DL systems (Section III.F).

C. UP-FRONT INVESTMENT

- Conversion to DL courseware requires an up-front investment while resident training programs continue; financial payback in the form of travel, per diem, and schoolhouse cost savings begins as DL comes on line and resident courses are phased out or reduced (Section IV.E).
- Estimates of costs to convert conventional schoolhouse instruction to DL courseware vary widely. Service investment cost estimates for RC DL are sizable, varying from about $500M to $1,800M. However, eliminating duplication among the 1,097 courses that the Services independently propose to convert to DL would reduce these conversion costs (Section III.B).

D. DL CONVERSION PLANS

- The Services plan to convert about 19 percent of their courses (1,097 of 5,847) for RC training to DL. Although the Navy plans to convert only one percent of its courses (27 of 2,433) for RC training, the Navy already has about 600 DL courses in a print format (Section II).
- While the Navy and Air Force plans indicate 100 percent conversion of all prospective DL courses, the Army plan calls for 100 percent DL conversion of only 7 of 532 courses suitable for conversion (Section II, Table 4). Thus, most Army RC personnel in DL courses would still travel to resident training sites.

E. JOINT SERVICE DL

- Configuration standards are essential to ensure DL interoperability among the Services and among elements within each Service (Section III.D).
- Joint management of DL courseware development is needed to avoid duplication of course material; joint-Service courseware can be used in many cases in which Service courses—whole or in part—are the same or similar to those of another Service (Section III.D).

F. DATA GAPS AND DL INVESTMENT DECISIONS

- Data furnished by the Services differ widely in quality and comprehensiveness. Despite some commendable efforts to respond conscientiously to the DepSecDef tasking, gaps and uncertainties remain in all Service plans for using DL in RC training (Sections II, IV).
- Service budgets provide no budget line items or budget exhibits under which funding for DL can be uniformly identified, tracked, and managed (Section II).
- Service plans do not identify the marginal cost of the schoolhouse infrastructure (instructors, training developers, training equipment, course maintenance, school operations, etc.) or discuss how implementing DL would affect the present schoolhouse infrastructure and costs (Section II.C).
- Opportunities to use DL technologies to train 1.6 million personnel in the ACs and 900,000 DoD civilians, either in residence or at a distance, have not been compiled or studied (Section III.C).
- Effective strategic plans for RC training cannot be devised without full consideration of Total Force training strategies and plans (Section IV.E). With few exceptions, the content of courses is the same for AC and RC personnel in the same job occupations. Thus, DL Courseware could be used by the Total Force, whose larger population makes the economics of using DL technologies more attractive.

VI. RECOMMENDATIONS

Based on the above findings, senior representatives from the Office of the Secretary of Defense, the Joint Staff, the four Military Services, and other Defense Agencies should

1. Examine DL in a Total Force context: all Services, all components, and DoD civilians. This should include schoolhouse infrastructure cost, DL infrastructure cost, travel and per diem costs, costs associated with resident training, and a thorough review of the costs of converting conventional classroom courses to DL technologies, and expected improvement in both training efficiency and personnel readiness.

2. Prepare a cohesive, Defense-wide action plan for DL that fully capitalizes on the opportunities provided by DL technologies and, if anticipated improvements in training efficiency and personnel readiness warrant, identify milestones that expeditiously move the plan forward for implementation. This action plan should address the need for developing a DoD organizational structure to assist in:

   - Guiding and assessing the application of DoD DL technologies in a Total Force context that includes ACs, RCs, and the Defense civilian workforce;
   - Ensuring that DoD DL technologies are developed, managed, and used in a cost-effective manner; and,
   - Identifying and enforcing configuration standards for DoD DL technologies.

REFERENCES

1. Deputy Secretary of Defense, *Program Decision Memorandum (PDM) II*, Directed Study 33, Distance Learning Technologies, 27 October 1994, unclassified part of Secret PDM.

2. Assistant Secretary of Defense (Reserve Affairs), Memorandum for Assistant Secretaries of the Army (M&RA), Navy (M&RA), and Air Force (MRAI&E), Subject: Directed Study on Distance Learning Technologies, 2 February 1995.

3. U.S. Army Training Support Center, *Distance Learning Conversion*, Database, 27 June 1995.

4. Office of the Assistant Secretary of the Navy (Reserve Affairs), Memorandum for Assistant Secretary of Defense (Reserve Affairs), Subject: Directed Study on Distance Learning Technologies—Information Memorandum, 1 June 1995.

5. Office of the Assistant Secretary of the Air Force (Manpower, Reserve Affairs, Installations and Environment), Memorandum for Assistant Secretary of Defense (Reserve Affairs), Subject: Directed Study on Distance Learning Technologies, 1 June 1995.

6. U.S. Army Training and Doctrine Command (TRADOC), *Implementation Plan for the Distributed Training Strategy (Final Draft)*, 8 June 1990.

7. Headquarters, TRADOC, *Army Distributed Training Program*, Master Plan, 1 October 1991.

8. Air National Guard briefing (as amended) to Distance Education and Training Board of the Air Education and Training Command at McGhee Tyson AFB, 8 February 1995.

9. Orlansky, Jesse, and String, Joseph, *Cost-Effectiveness of Computer-Based Instruction in Military Training*, IDA Paper P-1375, April 1979.

10. Fletcher, J.D., *Effectiveness and Cost of Interactive Videodisc Instruction in Defense Training and Education*, IDA Paper P-2372, July 1990.

11. Redding, G.A., and Fletcher, J.D., "Technical and Administrative Issues in Distributed Training Technology," *Learning Without Boundaries*, Defense Research Series, Volume 5, Plenum Press, New York, 1994.

12. Johnston, R., and Fletcher, J.D., *The Effectiveness of Computer-Based Instruction in Military Training: A Meta-Analysis*, IDA Document D-1748, forthcoming.

13. Metzko, John, *Individual Training and Readiness in Support Forces of the Army Reserve Components*, Institute for Defense Analyses (IDA) Document D-1614, June 1995.

14. Military Standard, MIL-STD-1379D, *Military Training Programs*, Commander Naval Sea Systems Command, SEA 55Z3, Department of the Navy, 5 December 1992.

15. Video Teletraining Contract Cost Data (as amended) from VTT network contracts: CESN N00140-94-C-B092; TNET DABT60-90-D0005; CDV DOA200-87-11-0024.

16. National Defense Authorization Act for 1995, U.S. House of Representatives Report 103-747.

GLOSSARY

1V, 2A	one-way video, two-way audio
2D	two dimensional
2V, 2A	two-way video, two-way audio
3D	three dimensional
AC	active component
AFRES	Air Force Reserve
ANG	Air National Guard
ARNG	Army National Guard
ATN	Air Technology Network
ATRRS	Army Training Requirements and Resources System
B	billion
CAI	computer-aided instruction
CBT	computer-based training
CD	compact disc
CD-ROM	CD-read-only memory
CDV	compressed digital video
CESN	CNET Electronic Schoolhouse Network
CIF	common intermediate format
CMI	computer-managed instruction
CNET	Chief of Naval Education and Training
CPH	cost per hour
DepSecDef	Deputy Secretary of Defense
DISA	Defense Information Systems Agency
DL	Distance Learning
DoD	Department of Defense
FTS	Federal Telecommunications System
FY	fiscal year
GSA	General Services Administration
ICW	interactive courseware
ISDN	Integrated Services Digital Network

IVD	interactive videodisc
Kbps	kilobits per second
L	lease
M	million
M&RA	Manpower, Reserve Affairs
MIL-STD	Military Standard
MOS	military occupational specialty
MOSQ	MOS qualified
MRAI&RE	Manpower, Reserve Affairs, Installations, and Environment
NCO	non-commissioned officer
NQ	not qualified
NR	Naval Reserve
NTU	National Technological University
OSD	Office of the Secretary of Defense
P	purchase
PDM	Program Decision Memorandum
PMEC	Professional Military Education Center
POM	Program Objective Memorandum
Q	qualified
RC	reserve component
ROM	read only memory
SEP	Satellite Education Program
SEW	Satellite Education Network
TDY	temporary duty
TNET	Teletraining Network
TRADOC	Training and Doctrine Command
VT	video tape
VTC	video teleconferencing
VTT	video teletraining
WN	Warrior Network

APPENDIX A

CAI EVALUATION

APPENDIX A
CAI EVALUATION

Orlansky and String evaluated the effectiveness and cost of computer-assisted instruction (CAI) and computer-managed instruction (CMI) for military training on the basis of 30 studies involving 48 datasets and the 17 courses indicated in Table A-1.* In their evaluation, they compared four methods of instruction:

Conventional Instruction: group-paced lectures, and discussions.

Individualized Instruction: self-paced without computer support.

Computer-Assisted Instruction: computer stores and provides instructional materials to students individually via interactive terminals; computer tests and guides students; self-paced.

Computer-Managed Instruction: instructional materials and tests provided away from computer; computer scores and tests and guides students; self-paced.

Most (70 percent) of the data on CAI came from experiments with few students (up to 50) and limited course materials (1 day to 1 week). There are fewer studies of CMI but these involved more students (600 to 2,500) and longer courses (2 to 10 months). [As shown by Table A-1,] there is a wide range of subject matter in these studies, e.g., knowledge, theory, and hands-on performance skills; electronics machinist, recipe conversion, vehicle repair, fire-control technician.

Each of the 30 studies reported effectiveness. However, only eight of the studies that report effectiveness also provide some cost data. The latter data are limited to expenses incurred during the experiment and are incomplete with respect to costs of program management, maintenance and repair, instructional support, and other factors important in determining life-cycle costs.

There are two ways of evaluating the cost-effectiveness of alternative military systems. Given two systems of the same cost, one would prefer the system that provides greater effectiveness. Given two systems of the same level of effectiveness, one would prefer the system that costs less.

---

* Orlansky, Jesse, and String, Joseph, *Cost-Effectiveness of Computer-Based Instruction in Military Training*, IDA Paper P-1375, April 1979.

Table A-1. Courses Used in Various Studies of CAI and CMI

Courses	No. of Evaluations	
	CAI	CMI
Basic Electronics	15	
Electricity	5	
Machinist	2	
Training Materials Development	1	
Recipe Conversion	2	
Aircraft Panel Operation	1	
Medical Assistant	4	
Vehicle Repair	4	
Weather	1	
Tactical Coordinator (S-3A)	1	
Fire Control Technician	4	
Aviation Familiarization		2
Aviation Mechanical Fundamentals		2
Inventory Management		1
Materiel Facilities		1
Precision Measuring Equipment		1
Weapons Mechanic		1
Total	40	8

All [30] studies of computer-assisted and computer-managed instruction have used the second approach. Computer-based instructional systems have been designed to provide the same degree of effectiveness (student achievement) as the method of instruction they might replace (conventional instruction). Therefore, these alternative methods of instruction must be evaluated in terms of differences in their costs.

The effectiveness of computer-assisted and computer-managed instruction for military training has been measured only by student achievement at school and not by performance on the job. Correlations between performance at school and on the job have not been established for any method of instruction. Data on length of time required for students to complete a course (generally less for CAI and CMI than for conventional instruction) should be treated as a measure of the cost of instruction rather than a measure of its effectiveness. The same argument applies to academic attrition rate. The attitudes of students and instructors to CAI and CMI may be interesting; however, they are qualitative in nature and it is difficult to relate such data either to the cost or the effectiveness of instruction.

In the 30 studies, CAI or CMI was generally compared to conventional instruction; the time savings found in these comparisons may be due to a combination of self-pacing, computer support, and revised and possibly reduced course material.

CONCLUSIONS

Student Achievement. Student achievement in courses at military training schools with computer-assisted instruction is the same as or greater than that with conventional instruction; the amount of additional achievement is small and has little practical importance. Student achievement in course with computer-managed instruction is about the same as that with conventional instruction. Both of these results are due to keeping students in CAI and CMI courses until they achieve standards set previously for conventional instruction.

Student Time Saving. Computer-assisted and computer-managed instruction in military training save about 30 percent of the time (median value) needed by students to complete the same courses given by conventional instruction. The amounts of time reported as saved vary widely, but little attention has been given to the factors that could account for the wide variation. Most of the results on computer-assisted instruction come from experiments of limited duration, with limited amounts of course materials, and with relatively few students. Where computer-managed instruction has been used for extended periods (up to 4 years), the initial time savings have been maintained or increased.

The above conclusions are shown in summary form in Table A-2 along with findings related to other measures. The sources of the studies evaluated by Orlansky and String are identified in Table A-3.

Table A-2. Summary of Findings on CAI and CMI, Compared to Conventional Instruction

Measure	Finding (Compared to Conventional Instruction)		Comments
	CAI	CMI	
Student Achievement	Same or more	Same	Performance measured only at school. Relation between performance at school and on the job not measured. Observed differences not of practical importance.
No. of Comparisons	40	8	CMI: Most time savings maintained or increased with extended use.
Time saved (Median)	29%	44%	
Range	−31 to 89%	12 to 69%	
No. of Comparisons	5	7	Computer support saves little time beyond that of individualized instruction.
Time saved			
• Individualized Instruction	64%		
• CAI, CMI	69%	51%	
Student Attrition	About the same	Slight increase may occur	CAI: Very limited data. CMI: Possible decline in student quality.
Student Attitudes	Favorable	Favorable	
Instructor Attitudes	Unfavorable	Unfavorable	Very limited data. Little attention given to instructors.
Cost	Less, due to student time savings	Less, due to student time savings	Data limited and incomplete.
Cost-effectiveness			Not known because cost data are limited and incomplete.

Table A-3. Source Studies for Evaluation of Various Methods of Instruction

Carson, S.B., L.L. Graham, L.G. Harding, K.A. Johnson, G.D. Mayo, and P.A. Salop, *An Evaluation of Computer-Managed Instruction in Navy Technical Training*, Navy Personnel Research and Development Center, San Diego, California, TR 75-38, June 1975 (AD A012 638).

Crawford, A.M., and Kent S. Crawford, "Simulation of Operational Equipment with a Computer-Based Instructional System: A Low-Cost Training Technology," *Human Factors*, 20:215–224, 1978.

Crawford, A.M., R.E. Hurlock, R. Padilla, and A. Sassano, *Low-Cost Part-Task Training Using Interactive Computer Graphics for Simulation of Operational Equipment*, Navy Personnel Research and Development Center, San Diego, TR 76 TQ-46, August 1976 (AD A029 540).

Dallman, B.E., P.J. DeLeo, P.S. Main, and D.C. Gillman, *Evaluation of PLATO IV in Vehicle Maintenance Training*, Air Force Human Resources Laboratory, Technical Training Division, Lowry AFB, Colorado, AFHRL TR 77-59, November 1977.

Deignan, G.M., *Interim Report on the Evaluation of CAI in Three Air Force Medical Training Courses* (memorandum), Air Force Human Resources Laboratory, Technical Training Division, Lowry AFB, Colorado (no date).

Deignan, G.M., and R.E. Duncan, *CAI in Three Medical Training Courses: It Was Effective!*, Air Force Human Resources Laboratory, Colorado, paper presented to the National Conference on the Use of On-Line Computers in Psychology, 7th Annual Meeting, Washington, D.C., November 9, 1977.

Downs, A.B., 2nd Lt. L.E. Johnson, MSgt T.W. Barnes, TSgt F.J. Wolfe, and D.M. Williams, *Keesler Test of Lincoln Training System (LTS) Feasibility for Air Traffic Control Operator Training*, Keesler AFB, Mississippi, KE PR 72 113, 29 August 1972.

Ford, John D., Jr., and Dewey A. Slough, *Development and Evaluation of Computer Assisted Instruction for Navy Electronic Training: I. Alternating Current Fundamentals*, Navy Personnel and Training Research Laboratory, San Diego, California, Research Report SSR 70 32, May 1970.

Ford, John D., Jr., Dewey A. Slough, and R.E. Hurlock, *Computer Assisted Instruction in Navy Technical Training Using a Small Dedicated Computer System*, Final Report, Navy Personnel and Training Research Laboratory, San Diego, California, Research Report SSR 73 13, November 1972 (AD 752 999).

Fredericks, P.S., and L.B. Hoover-Rice, *Computer-Based Training of Recipe Conversion with Lower Aptitude Personnel*, Navy Personnel Research and Development Center, San Diego, California, TR 77-24, April 1977 (AD A038 420).

General Electric Ordnance Systems, *Computer Based Instruction Evaluation Project*, Final Report, Vol. 1: "Conduct and Results of the Computer Based Instruction Evaluation," Pittsfield, Massachusetts, 15 July 1975.

Giunti, F.E., and A.A. Longo, *An Evaluation of CAI in Basic Electronics Training*, report presented to the Association for the Development of Instructional Systems at the State University of New York at Stony Brook, Stony Brook, New York, 1–3 February 1971.

Giunti, F.E., and A.A. Longo, *An Interim Evaluation of the Tutorial Mode of CAI in Army Basic Electronics Training*, report presented at the Annual Convention of the Northeastern Educational Research Association, Grossinger, New York, 9–12 November 1971.

Harris, W.P., M. Grossberg, A.B. Downs, 2nd Lt. L.E. Johnson, MSgt T.W. Barnes, and H.M. Clark, *Keesler Test of Lincoln Training System (LTS) Feasibility*, Keesler AFB, Mississippi, KE PR 72 112, 31 July 1972.

Hurlock, R.E., *Applications of Pretest Branching Designs to CAI Basic Electronics Training*, Navy Personnel and Training Research Laboratory, San Diego, California, Research Report SSR 73-8, September 1972.

Hurlock, R.E., and G.F. Lahey, *Development and Evaluation of Computer-Assisted Instruction: 2. Inductance*, Navy Personnel and Training Research Laboratory, San Diego, California, Research Report SSR 71-22, May 1971.

International Business Machines Corporation, *A Feasibility Study of Computer-Assisted Instruction in U.S. Army Basic Electronics Training*, final report, Contract No. DAAB 07 76 C 0578, Gaithersburg, Maryland, February 1968.

Keesler Air Force Base, *A Comparison of Hardware vs. "Courseware" in CAI*, Keesler AFB, Mississippi, KE PR 73-118, 15 April 1974.

Keesler Air Force Base, *Training High-Aptitude Self-Paced Students on the Lincoln Training System (LTS)*, Keesler AFB, Mississippi, KE PR 72-118, 28 November 1972.

Keesler Air Force Base, *Supplementary Study of Peer Training with the Lincoln Training System*, Keesler AFB, Mississippi, KE PR 73-123, 25 July 1973.

Lahey, G.F., A.M. Crawford, and R.E. Hurlock, *Learner Control of Lesson Strategy: A Model for PLATO IV System Lessons*, Navy Personnel Research and Development Center, San Diego, California, TR 76-36, June 1976 (AD A025 249).

Longo, A.A., *The Implementation of Computer-Assisted Instruction in U.S. Army Basic Electronics Training: Follow-up of a Feasibility Study*, U.S. Army Signal Center and School, Ft. Monmouth, New Jersey, TR 69-1, September 1969.

Longo, A.A., *A Summative Evaluation of Computer-Assisted Instruction in U.S. Army Basic Electronics Training*, U.S. Army Signal Center and School, Ft. Monmouth, New Jersey, TR 72-1, May 1972.

McDonnell Douglas Astronautics Company-East, *Integrated System Test of the AIS, Executive Summary* (draft), McDonnell Douglas Astronautics, St. Louis, Missouri, 14 October 1977.

McDonnell Douglas Astronautics Company-East, *Advanced Instructional System* (briefing material), 1977.

McDonnell Douglas Astronautics Company-East, *A Survey and Analysis of Military Computer-Based Training Systems*, Vol. II, McDonnell Douglas Astronautics, St. Louis, Missouri, 1977 (AD A043 358).

Radsken, J.W., and J.F. Grosson, "An Evaluation of Computer Based Instruction for Performance of 'Hands-On' Training Evolutions," *8th NTEC Industry Conference Proceedings*, Naval Training Equipment Center, Orlando, Florida, pp. 221–226, 18–20 November 1975.

Slough, Dewey A., and J.D. Coady, *Strategies for Computer Guidance of Oscilloscope Training*, Navy Personnel Research and Development Center, San Diego, California (in preparation).

Steinkerchner, Major Raymond E., G.M. Deignan, Major B.K. Waters, and P.J. DeLeo, *Computer-Assisted Instruction in Air Force Medical Training: Preliminary Findings*, Air Force Human Resources Laboratory, Technical Training Division, Lowry AFB, Colorado, AFHRL TR 77-17, May 1977 (AD A043 650).

Stern, H.W., *Transfer of Training Following Computer-Based Instruction in Oscilloscope Procedures*, Navy Personnel Research and Development Center, San Diego, California, TR 76-1, July 1975 (AD A012 637).

U.S. Army Ordnance Center and School, *Evaluation of the PLATO IV System in a Military Training Environment*, Vols. 1 and 2, U.S. Army Ordnance Center and School, Aberdeen Proving Ground, Maryland, 1975.

Walker, Richard A., *Post Hoc Evaluation of S-3A Instructional Systems Development Plan*, Courseware, Inc., San Diego, California, 15 February 1978.

APPENDIX B

IVD EVALUATION

APPENDIX B
IVD EVALUATION

Fletcher used a "meta-analytic" technique to review the effectiveness and cost of interactive videodisc (IVD) instruction.* The review involved 47 comparisons derived from 28 studies of the effectiveness of IVD applications in training and education. Table B-1 identifies sources of the studies. (More than 28 sources are referenced inasmuch as some studies were reported by two sources.) The baseline for comparing IVD instruction with conventional instruction involved three instructional settings: military training, industrial training, and higher education.

The meta-analytic approach, which is an analysis of analyses, uses (1) a quantitative measure called "effect size" to tabulate the outcomes of collected studies including those whose results are not statistically significant and (2) statistical procedures to synthesize the quantitative measures and describe the findings. The studies are made comparable by converting them to an effect size (ES) metric, which is defined as the standardized mean difference in test scores of experimental (e) and control (c) groups. Thus, $ES = (\overline{x}_e - \overline{x}_c)/S_c$, where $\overline{x}$ is the mean test score and S is the standard deviation.

FINDINGS

Fletcher's findings, which follow, concern the instructional capabilities provided by IVD systems, not the hardware itself.

1. Effectiveness

Interactive videodisc instruction was used successfully to teach. Four comparisons of interactive videodisc instruction with a "placebo" treatment, in which no relevant instruction was given, resulted in an average increase in achievement of 1.39 standard deviations, or, roughly, an increase in the achievement for 50th percentile students to about the 92nd percentile of achievement.

---

* Fletcher, J.D., *Effectiveness and Cost of Interactive Videodisc Instruction in Defense Training and Education*, IDA Paper P-2372, July 1990.

Overall, interactive videodisc instruction was more effective than conventional instruction. Forty-seven comparisons of interactive videodisc instruction with conventional approaches were identified for this review. Over all instructional settings (military training, industrial training, higher education), instructional approaches (simulation only, tutorial only, simulation and tutorial combined), and outcomes (knowledge, performance, retention), interactive videodisc instruction increased achievement an average of 0.50 standard deviations over conventional instruction (an increase for 50th percentile students to about the 69th percentile of achievement).

Interactive videodisc instruction was more effective than conventional instruction in military training. Twenty-four comparisons of interactive videodisc instruction with conventional approaches to military maintenance, operator, and command training were identified for this review. Over all instructional approaches and outcomes, they showed an average increase in achievement of 0.38 standard deviations (an increase for 50th percentile students to about the 65th percentile of achievement).

Interactive videodisc instruction was more effective than conventional instruction in higher education. Fourteen comparisons of interactive videodisc instruction with conventional approaches to instruction in higher education settings (colleges and universities) were identified for this review. Over all instructional approaches and outcomes, they showed an average increase in achievement calculated using pooled standard deviations of 0.69 standard deviations (an increase for 50th percentile students to about the 75th percentile of achievement). The lower average effect sizes found for military training than for higher education may be due to a focus in military training on reaching threshold level(s) of achievement with minimized costs and time so that students who reach achievement criteria are sent on to duty assignments rather than held in the instructional setting as they are in higher education.

Interactive videodisc instruction was equally effective for both knowledge and performance outcomes. The average effect sizes calculated using pooled standard deviations for 27 knowledge outcomes (facts, concepts, and other information students acquired) and for 20 performance outcomes (procedures, skills, and other capabilities students could demonstrate) both averaged around 0.35 standard deviations (suggesting an improvement of 50th percentile students to about the 64th percentile).

The more the interactive features of interactive videodisc technology were used, the more effective the resulting instruction. One study examined this issue directly and found greater achievement with greater levels of interactivity. The

issue can also be examined by comparing the effect sizes for Level II videodisc instruction (–.70, overall) with those for Level III videodisc instruction (.50, overall).

Directed, tutorial approaches were more effective than stand-alone simulations in interactive videodisc instruction. Effect sizes averaged 0.70 for tutorial approaches, 0.40 for combined tutorial and simulation approaches, and 0.15 for simulations by themselves.

Within-group variability was smaller in interactive videodisc instruction than in conventional instruction. In nearly every comparison of interactive videodisc instruction with conventional instruction, achievement in the interactive videodisc instruction group was less variable than in the conventional instruction group, suggesting there was more equitable distribution of achievement using interactive videodisc instruction.

Interactive videodisc instruction was more effective than computer-based instruction without videodisc interaction. Both interactive videodisc instruction and computer-based instruction have been found to be more effective than conventional instruction. However, the average effect size of around 0.69 observed for interactive videodisc instruction used in colleges is considerably higher than both the average effect size of 0.26 found in a review of computer-based instruction used in colleges and the average effect size of 0.42 found in a review of computer-based instruction used in adult education.

There was little in the reviewed studies to indicate how interactive videodisc instruction achieves its success. The studies examined in this review did little to indicate which features of interactive videodisc instruction contribute to the observed increases in student achievement. In addition, there are many outcomes—such as speed of response, accuracy of response, attitude toward the subject matter, insight, transfer, and retention—that alone or in some combination may become the objective(s) of instruction. How different designs for interactive videodisc instruction contribute to accomplishing these different outcomes was rarely addressed by the reviewed studies and remains a proper topic for future research.

2. Cost

Interactive videodisc instruction was less costly than conventional instruction. All 13 cost ratios (the ratio of costs for interactive videodisc instruction over costs for conventional instruction) found for this review were less than 1.0, indicating

lower costs in every measured instance for interactive videodisc instruction. The average across all 13 cost ratios was 0.36. The average amount of student time saved across the studies covered by this review was 31 percent, suggesting another source of savings from use of interactive videodisc instruction. Reductions in total military manpower that can result from such time savings in training may be an additional, significant source of cost savings, but this possibility was not examined here.

3. Cost-Effectiveness

Interactive videodisc instruction was more cost-effective than conventional instruction. Interactive videodisc instruction was found to be both less costly in all studies that reported costs and more effective overall than the conventional approaches with which it was compared. This finding should be viewed as suggestive rather than conclusive, since no studies were found that used systematic models to provide empirical data on both cost inputs and effectiveness outputs.

4. Time on Task

Interactive videodisc instruction may increase time on task. Only one study reported an observation relative to this point. This study reported a 45 percent increase in the time spent practicing a targeted task as a result of the introduction of interactive videodisc instruction. This result was viewed as promising, but not conclusive.

5. Retention

Interactive videodisc instruction seems unlikely to affect retention. Four studies addressed retention. Both negative and positive results moved closer to zero over the retention intervals considered in these studies. Post-training experiences typically influence retention of knowledge and performance in a powerful manner. Findings for interactive videodisc training corroborate other Defense experiences with new training approaches that suggest their value lies primarily in improving the efficiency of instruction, not in assuring longer retention.

CONCLUSION

The Fletcher meta-analysis showed interactive videodisc instruction is both more effective and less costly than conventional instruction. The 47 comparisons suggest, therefore, that interactive videodisc instruction can have a significant positive impact on

military training and education. Although more needs to be learned about how interactive videodisc instruction should be designed and employed, it should now be routinely considered and used in military training and education.

Table B-1. Source Studies for Meta-Analysis of the Effectiveness of IVD Applications in Training and Education

Allan, D.M.E. (1989). *The effectiveness of interactive videodisc in clinical medical education.* San Diego, CA: Intelligent Images, DAROX Corporation.

Aukerman, M.E. (1986). *Effectiveness of an interactive video approach for CPR recertification of registered nurses.* (Doctoral Dissertation, University of Pittsburgh, Pittsburgh, PA) (University Microfilms No. 8620270).

Bosco, J., and Wagner, J. (1988). A comparison of the effectiveness of interactive laser disc and classroom video tape for safety instruction of General Motors workers. *Educational Technology, 28*, 15–22.

Bunderson, C.V., Olsen, J.B., and Baillio, B. (1981). *Proof-of-concept demonstration and comparative evaluation of a prototype intelligent videodisc system.* Orem, UT: Learning Design Laboratories, WICAT, Inc.

Bunderson, C.V., Baillio, B., Olsen, J.B., Lipson, J.I., and Fisher, K.M. (1984). Instructional effectiveness of an intelligent videodisc in biology. *Machine-Mediated Learning, 1*, 175–215.

Cicchinelli, L.F. (1984). Evaluation of the electronic equipment maintenance trainer (EEMT): Individualized troubleshooting training. In *Proceedings of Ninth Symposium on Psychology in the Department of Defense, Colorado Springs, CO, 1984.* Denver, CO: University of Denver, Denver Research Institute. (DTIC No. AD-P003 317).

Cicchinelli, L.F., Keller, R.A., and Harmon, K.R. (1984). *Training capabilities test of electronics equipment maintenance trainer (EEMT): Findings and conclusions* (Technical Report No. 158). Orlando, FL: Training Analysis and Evaluation Group, Naval Training Equipment Center.

Crotty, J.M. (1984). *Instruction via an intelligent videodisc system versus classroom instruction for beginning college French students: A comparative experiment.* (AFIT/CI/NR 84-51D). Wright-Patterson AFB, OH: Air Force Institute of Technology/NR. (DTIC No. AD-A145 599). (University Microfilms No.8513797).

Davis, B.G. (1985). *Nebraska videodisc science laboratory simulations: Executive summary (and) science lab videodiscs: Evaluation report.* Washington, DC: The Annenberg/CPB Project. (ERIC No. ED 264 821).

Fowler, B.T. (1980). *The effectiveness of computer-controlled videodisc-based training.* (Doctoral Dissertation, University of Iowa, Iowa City, IA) (University Micofilms No. 8114254).

Gibbons, A.S., Lines, V., and Cavagnol, R.M. (1983). *Distributed instructional system project: Final report* (TDI-TR-83-5). Fort Monroe, VA: U.S. Army Training and Doctrine Command and Fort Bliss, TX: U.S. Army Air Defense Artillery School.

Green, E.K., Beger, R.E., and Dunlap, S.W. (1986). *Economic analysis to support a training development options paper for AN/BQQ-5 maintenance training* (Special Report 86-002). Orlando, FL: Training Analysis and Evaluation Center, Naval Training Equipment Center.

Holmgren, J.E., Dyer, F.N., Hilligoss, R.E., and Heller, F.H. (1979). The effectiveness of Army training extension course lessons on videodisc. *Journal of Educational Technology Systems, 8*, 263–274.

Jones, L.L. (1987). Videodisc laboratory for chemistry. In *Proceedings of the Optical Information Systems Conference, December, 1987* (pp. 157–165).

Jones, L.L. (1988). Enhancing instruction in the practice of chemistry with the computer-assisted interactive videodisc. *Trends in Analytical Chemistry, 7*, 273–276.

(continued)

Table B-1. (continued)

Ketner, W.D. (1984). Interactive videodisc for electronic equipment simulation. In *Proceedings of the Second Annual Conference on Interactive Instruction Delivery in Education, Training, and Job Performance.* Warrenton, VA: Society for Applied Learning Technology.

Kimberlin, D.A. (1982). The U.S. Army Air Defense School distributed instructional system project evaluation. In *Proceedings of the Fourth Annual Conference on Interactive Videodisc in Education and Training.* Warrenton, VA: Society for Applied Learning Technology.

King, F.J. (1982). Evaluation of a videodisc delivery system for teaching students to troubleshoot the AN/VRC-12 medium-powered radio series. Fort Monroe, VA: Training Developments Institute, U.S. Army Training and Doctrine Command. (DTIC No. AD-A157 890).

King, J.M., and Reeves, T.C. (1985). *Evaluation of an interactive microcomputer-videodisc delivery system for training in military operations on urbanized terrain (MOUT).* Fort Eustis, VA: U.S. Army Training Support Center and Fort Benning, GA: U.S. Army Infantry Center and School.

Lyness, A.L. (1987). *Performance and norms of time for adult learners instructed in CPR by an interactive videodisc system.* Paper presented at the Fifth Annual Conference on Research in Nursing Education, San Francisco, CA. (ERIC No. ED 281 986).

Malec, V.M., and Luszczak, M. (1987). *Field evaluation of interactive simulation for maintenance training: SH-3 helicopter electro-mechanical bladefold system* (NPRDC TR 88-2). San Diego, CA: Navy Personnel Research and Development Center.

North, M. (1988). *Interactive videodisc training effectiveness study: Tellabs 244 Data Bridge.* Santa Monica, CA: North Communications.

Pieper, W.J., Richardson, J.J., Harmon, K.R., Keller, R.A., and Massey, R.H. (1984). *Interactive graphics simulator: design, development, and effectiveness/cost evaluation* (AFHRL-TR-84-38). Brooks AFB, TX: Air Force Human Resources Laboratory.

Schroeder, J.E., Dyer, F.N., Czerny, P., Youngling, E.W., and Gillotti, D.P. (1986). *Videodisc interpersonal skills training and assessment (VISTA): Overview and findings, Volume 1* (ARI Technical Report 703). Fort Benning, GA: U.S. Army Research Institute Field Unit.

Schroeder, J.E., Hall, S., and Morey, J.C. (1985). Appendix M: Statistical results of the evaluation. In Schroeder, J.E., Dyer, F.N., Czerny, P., Youngling, E.W., and Gillotti, D.P. *Videodisc interpersonal skills training and assessment (VISTA): Software and evaluation details, Volume IV* (Research Note). Fort Benning, GA: U.S. Army Research Institute Field Unit.

Smith, S.G., and Jones, L.I. (1989). Images, imagination, and chemical reality. *Journal of Chemical Education, 66,* 8–11.

Smith, S.G., Jones, L.L. and Waugh, M.L. (1986). Production and evaluation of interactive videodisc lessons in laboratory instruction. *Journal of Computer Based Instruction, 13,* 117–121.

Spencer, J. (1983). *IVIS Benchmark Study.* Bedford, MA: Educational Services Division, Digital Equipment Corporation.

Stevens, S.M. (1984). *Surrogate laboratory experiments: Interactive computer/videodisc lessons and their effect on students' understanding of science.* (Doctoral dissertation, University of Nebraska, Lincoln, NE) (University Microfilms No. 8428209).

(continued)

Table B-1. (continued)

Verano, M. (1987). *Achievement and retention of Spanish presented via videodisc in linear, segmented, and interactive modes.* (Doctoral dissertation, University of Texas, Austin, TX) (DTIC No. AD-A185 893).

Vernon, C.D. (1984). *Evaluation of interactive video disc system for training the operation of the DCT-9000 in the MOS 72G course.* Fort Eustis, VA: U.S. Army Communicative Technology Office and Fort Gordon, GA: U.S. Army Signal School. (DTIC No. AD-A157 856).

Williams, K.E., and Harold, L.J. (1985). *AN/BQQ-5 interactive video disc training effectiveness evaluation final report.* Orlando, FL: Naval Training Equipment Center.

Wilkinson, G.L. (1983) *An evaluation of equipment-independent maintenance training by means of a microprocessor-controlled videodisc delivery system* (Report TDI-TR-83-1). Fort Monroe, VA: U.S. Army Training and Doctrine Command (DTIC No. AD-A127-011).

Wilkinson, G.L. (1985). *Evaluation of the effectiveness and potential application of the interactive videodisc instructional delivery system within the training of SIGINT/EW systems repairers, CMF33.* Fort Eustis, VA: U.S. Army Communicative Technology Office and Fort Devens, MA: U.S. Army Intelligence School. (DTIC No. AD-A157 942).

Winkler, J.D., and Polich, J.M. (In press) *Effectiveness of interactive videodisc in Army communications training.* Santa Monica, CA: RAND Corporation.

Young, J.I., and Tosti, D.T. (1981). *The use of videodisc and microprocessor in equipment simulation* (Report TDI-TR-81-3). Fort Monroe, VA: U.S. Army Training and Doctrine Command.

APPENDIX C

CBI EVALUATION

APPENDIX C
CBI EVALUATION

In a study of issues related to distance training technologies, Redding and Fletcher gathered data from many different evaluations to get an overall view of the effectiveness of interactive courseware (ICW).* In addition to considering Fletcher's findings on interactive videodisc (IVD), which appear in Appendix B, Redding and Fletcher presented results of numerous studies of computer-based instruction (CBI). These studies used the meta-analytic methodology described in Appendix B. The measure of effectiveness is "effect size," which is the difference between the test-score means (of an experimental group and a control group) divided by the standard deviation of the control group or by the standard deviation of the pool of the control and experimental groups. Table C-1 summarizes effect sizes for almost 200 studies of CBI in various settings.

Table C-1. Effect Sizes for CBI

Setting	Effect Size	Number of Studies	Percentile Improvement in Achievement[a]	Researchers[b]
Elementary School	.47	28	50 → 68	Kulik, C-L Kulik, Bangert-Drowns
Secondary School	.40	42	50 → 65	Bangert-Drowns, C-L Kulik, Kulik
Higher Education	.26	101	50 → 60	C-L Kulik, Kulik
Adult Education	.42	24	50 → 66	Kulik, C-L Kulik, Shwalb

[a] Average student achievement in traditional instruction mode improved using CAI.

[b] References in Table C-2.

Redding and Fletcher also cite an examination by Niemiec and Walberg of reviews of computer-assisted instruction (CAI) effectiveness. The Niemiec-Walberg examination covered 16 reviews and over 500 studies. Because of overlap—including Table C-1

* Redding, G.A., and Fletcher, J.D., "Technical and Administrative Issues in Distributed Training Technology," *Learning Without Boundaries*, Defense Research Series, Volume 5, Plenum Press, New York, 1994.

studies—Niemiec and Walberg estimate the number of "primary studies is close to 250." Three of the sixteen studies were "traditional, implicit, and nonquantitative." Thirteen were quantitative and explicit; eleven of these used meta-analytic methodology and provided numerical estimates of effect size. The mean and median effect sizes are both 0.42, thus placing the average student using CAI at the 66th percentile of traditional groups.

All three nonquantitative reviews covered by Niemiec and Walberg also concluded that CAI is effective. Among the narrative conclusions, the following comments—one from each review—address the time-savings aspect of CAI:

> The evidence clearly indicates that CAI will teach at least as well as live teachers or other media, that there will be a savings in time to learn, that students will respond favorably to CAI [based on 15 studies of instruction at the elementary school, secondary school, and college levels].
>
> At the secondary school and college levels, a conservative conclusion is that CAI is about as effective as traditional instruction [and] it may also result in substantial savings of student time in some cases [based on 22 studies of instruction].
>
> Achievement gains over other more traditional methods are the norm. . . . Retention is equal to that obtained in traditional instruction. . . . Perhaps the most valuable finding in the long run is that many CAI students gain mastery status in a shortened period of time [based on 66 studies of instruction at the secondary school level].

Table C-2 identifies the source studies used by Redding and Fletcher in their examination of the effectiveness of ICW.

Table C-2. References for Redding-Fletcher Study of ICW

Bangert-Drowns, R.L., Kulik, J.A., Kulik, C-L.C. (1985). Effectiveness of computer-based education in secondary schools. *Journal of Computer Based Instruction, 12,* 59–83.

Kulik, C-L.C., Kulik, J.A., and Shwalb, B. (1986). Effectiveness of computer-based instruction in adult education. *Journal of Educational Computing Research,* 2, 235–252.

Kulik, J.A., and Kulik, C-L.C. (1986). Effectiveness of computer-based education in colleges. *AEDS Journal, 19,* 81–108.

Kulik, J.A., Kulik, C-L.C., and Bangert-Drowns, R.L. (1985). Effectiveness of computer-based education in elementary schools. *Computers in Human Behavior,* 1, 59–74.

Niemiec, R., and Walberg, H.J. (1987). Comparative effects of computer-assisted instruction: A synthesis of reviews. *Journal of Educational Computing Research,* 3, 19–37.

APPENDIX D

CBT EVALUATION

APPENDIX D
CBT EVALUATION

Johnston and Fletcher reviewed 33 empirical studies that compared computer-based training (CBT) with conventional instruction in a military training environment.* Thirteen of the studies are among the 30 studies reviewed by Orlansky and String in Appendix A. The Fletcher-Johnston review involved using the effect-size methodology (described in Appendix B) to measure the difference in mean test scores of two groups in terms of standard deviations. The standardized mean difference, effect size (ES), is defined by $ES = (\bar{x}_e - \bar{x}_c)/S$, where $\bar{x}$ is the mean test score, S is the standard deviation, and e and c denote experimental and control groups, respectively.

In their meta-analysis of the 33 studies of military training, Johnson and Fletcher determined that ES = 0.44. Thus, CBT raised test scores by 0.44 standard deviations, which means the average student's percentile score was raised from 50 to 67.

In a subset of 23 of the 33 studies, Johnston and Fletcher were able to measure average time savings for the military training courses. They found a 30 percent reduction in instruction time when CBT was used. That result is consistent with the 30 percent time savings that Orlansky and String found, which is not surprising since 11 of the 23 Johnson-Fletcher studies were considered by Orlansky and String.

Table D-1 identifies the 33 studies reviewed by Johnson and Fletcher.

---

* Johnston, R., and Fletcher, J.D., *The Effectiveness of Computer-Based Instruction in Military Training: A Meta-Analysis*, IDA Document D-1748, forthcoming.

Table D-1. References to Fletcher-Johnson Study of CBT

Blevins, B.C., and Phipps, L.M., *Feasibility of Computer-Assisted Instruction*, Technical Report prepared for the Office of the Adjutant General, Department of the Army, 1980.

Crawford, A.M., Hurlock, R.E., Padilla, R., and Sassano, A., *Low Cost Part-Task Trainer Using Interactive Computer Graphics for Simulation of Operational Equipment*, Navy Personnel Research and Development Center, San Diego, CA, NPRDC Technical Report No. TQ76-46, 1976.

Dallman, B.E., and DeLeo, P.S., *Evaluation of PLATO IV in Vehicle Maintenance Training*, Air Force Human Resources Laboratory, AFHRL Publication No. AFHRL-TR-77-59, 1977.

Deignan, G.M., Seager, B.R., Kimball, M., and Horowitz, N.S., *Computer-Assisted, Programmed Text, and Lecture Modes of Instruction in Three Medical Training Courses: Comparative Evaluation*, Air Force Human Resources Laboratory, Technical Training Division, Lowry Air Force Base, CO, AFHRL Publication No. AFHRL-TR-79-76, 1980.

Dick, R.A., Royal, J.W., Simpson, H.K., and Mackie, R.R, *Personnel Technology: Using an Inexpensive Computer-Based System To Teach Performance-Oriented Skill*, Office of Naval Research, Report No. AD-785-029, 1974.

Dossett, D.L., and Hulvershorn, P., "Increasing Technical Training Efficiency: Peer Training via Computer-Assisted Instruction," *Journal of Applied Psychology*, Vol. 68, No. 4, 1983, pp. 552–558.

Downs, A.B., Johnson, L.E., Barnes, T.W., Wolfe, F.J., and Williams, D.M., *Keesler Test of Lincoln Training System (LTS) Feasibility for Air Traffic Control Operator Training*, Keesler Air Force Base, MS, Report No. KE PR 72-113, 1972.

Edwards, B.J., *Low-Cost Avionics Simulation for Aircrew Training*, Air Force Human Resources Laboratory, Brooks Air Force Base, TX, AFHRL Publication No. AFHRL-TR-85-38, 1986.

Ford, J.D., Slough, D.A., and Hurlock, R.E., *Computer-Assisted Instruction in Navy Technical Training Using a Small Dedicated Computer System*, Naval Personnel and Training Research Laboratory, San Diego, CA, Report No. SRR 73-13 (Final Report), 1972.

Fredricks, P. S., and Hoover-Rice, L.B., *Computer-Based Training of Recipe Conversion With Lower Aptitude Personnel*, Navy Personnel Research and Development Center, San Diego, CA, NPRDC Report No. TR 77-24, 1977.

General Electric Ordnance Systems, *Computer-Based Instruction Evaluation Project* (Final Report), General Electric, Pittsfield, MA, 1975.

Germas, J.E., and Baker, J.D., *Embedded Training: Utilization of Tactical Computers to Train Tactical Computer Operators*, U.S. Army Research Institute for Behavioral and Social Sciences, Technical Report 452, July 1980.

Graham, S.E., Shlechter, T.M., and Goldberg, S.L., *A Preliminary Evaluation of a Model Maintenance Training Program for Reserve Component Units*, U.S. Army Research Institute for the Behavioral and Social Sciences, Fort Knox, KY, Report No. RP 1421, 1986.

Harris, W.P., Grossberg, M., Downs, A.B., Johnson, L.E., Barnes, T.W., and Clark, H.M., *Keesler Test of Lincoln Training System (LTS) Feasibility*, Keesler Air Force Base, MS, Report No. KE PR 72-112, 1972.

Hausser, D., Blaiwes, A.S., Weller, D., and Spencer, G., *Application of Computer-Assisted Instruction to Interpersonal Skill Training*, University of Michigan, Ann Arbor, MI, Naval Training Equipment Center Report No. 74-C-0100-1, 1976.

(continued)

Table D-1. (continued)

Hill, C.E., Hall, F.A., and Wofford, B.R., *Evaluation of the PLATO IV System in a Military Training Environment*, Volumes 1 and 2, Aberdeen Proving Ground, Technical Report of the U.S. Army Ordnance Center and School, 1975.

Howard, F.S., *Distributed Training Pilot-MOS 75B Distributed Training Course Training Effectiveness Analysis*, U.S. Army TRADOC Analysis Center-White Sands, Report No. TEA-92-031, 1992.

Hoyt, W.G., and Baker, J.D, *The Use of Tactical Computers To Provide Weapons and Tactics Training to Combat NCOS: The Results of a Field Test*, U.S. Army Research Institute for the Behavioral and Social Sciences, Fort Knox, KY, Report No. TR 453, 1980.

Hull, G.L., *An Evaluation of the Student Interactive Training System at the U.S. Army Air Defense School*, U.S. Army Communicative Technology Office, Fort Eustis, VA, Report No. TR-84-2, 1984.

Hull, G.L., *Evaluation of the C2 CAI Console Operator Training Program for MOS 16H10 OSUT Students at the U.S. Army Air Defense School*, U.S. Army Training and Doctrine Command, Fort Monroe, VA, Report No. TDI-TR-82-6, 1982.

Hurlock, R.E., *Development and Evaluation of Computer-Assisted Instruction for Navy Electronics Training: 2, Inductance*, Naval Personnel and Training Research Laboratory, San Diego, CA, Report No. SRR 71-22, 1971.

International Business Machines Corporation, *A Feasibility Study of Computer-Assisted Instruction in U.S. Army Basic Electronics Training*, U.S. Army Signal Center and School, Fort Monmouth, NJ, Report No. DAAB-07-67-C-0578, 1968.

Keesler Air Force Base, *Training High-Aptitude Self Paced Students on the Lincoln Training System*, Keesler Air Force Base, MS, Report No. KE PR 72-118, 1972.

Longo, A.A., *A Summative Evaluation of Computer-Assisted Instruction in U.S. Army Basic Electronics Training*, U.S. Army Signal Center and School, Fort Monmouth, NJ, Report No. TR-72-1, 1972.

Mullis, C.W., and Scholtes, T.G., *Distributed Training Pilot: Voice-Based Language Training Development Study*, U.S. Army TRADOC Analysis Center-White Sands, Report No. TDS-92-028, 1993.

Pieper, W.J., Richardson, J.J., Harmon, K.R., and Keller, R.A., *Interactive Graphics Simulator: Design, Development, and Effectiveness/Cost Evaluation*, Air Force Human Resources Laboratory, Lowry Air Force Base, CO, AFHRL Report No. TR-84-38, 1984.

Sharkey, V.J., and Thomas, R.C., *The Evaluation of Two Automated Systems for Teaching Typewriting*, Naval Training Equipment Center, Report No. 1H-220, 1973.

Stern, H.W., *Transfer of Training Following Computer-Based Instruction in Basic Oscilloscope Procedures*, Navy Personnel Research and Development Center, San Diego, CA, 1975.

Wagner, W., *CAI Evaluation for Basic Typing in MOS 72G10 Communications Specialist Course*, Battelle Memorial Institute, Columbus Labs, Columbus, OH, Report No. TR 84-4, 1984.

Waldrop, G.P., White, V.T., and McDonald, L.B., *Computer-Assisted Instruction System Effectiveness on Troubleshooting Training*, Naval Training Equipment Center, Report No. 82-C-0119-1, 1983.

Walker, R.A., *Post Hoc Evaluation of S-3A Instructional Systems Development Plan*, Courseware, Inc., San Diego, CA, 1978.

(continued)

Table D-1. (continued)

Wetzel-Smith, S.K., Forgnoni, R.L., Richards, G.A., and Czech, C., *Evaluation of a Low Cost Microprocessor-Based Acoustic Analysis Training System*, Navy Personnel Research and Development Center, San Diego, CA, NPRDC Report No. TR 88-15, 1988.

Wisher, R.A., and O'Hara, *Computer-Based Approach to the Navy's Academic Remedial Training Project PREST: A Cost-Effectiveness Evaluation*, Navy Personnel Research and Development Center, San Diego, CA, NPRDC Report No. TR 81-18, 1981.

APPENDIX E

VTT EVALUATION

APPENDIX E
VTT EVALUATION

Several recent studies have examined the feasibility, effectiveness, and cost effectiveness of video teletraining (VTT): Defense Institute for Training Resources Analysis (DITRA) Study; Army Teletraining Network (TNET) Study; Army Satellite Education Program (SEP) Study; Army Command and General Staff College (C&GSC) Study; Chief of Naval Education and Training (CNET) Electronic Schoolhouse Network (CESN) Study; and Army Logistics Management College (ALMC) Study.

DITRA Study. A project undertaken in the early 1990's assessed the feasibility of using 2-year community colleges to deliver military programs of instruction using the Army TNET system.[1] The project involved Army Reserve Component Configured Courseware for three Military Occupational Specialty (MOS) courses:

71L10	Administrative Specialist
76Y10	Unit Supply Specialist
95B10	Basic Military Police

These courses were reconfigured from resident school format for live delivery over the TNET to Army National Guard and Army Reserve soldiers seeking reclassification into the indicated MOSs. All students passed the performance tests (PTs) for the three courses, and over 90 percent passed the PTs on their first attempt.

Army TNET Study. At about the same time that the above DITRA project was underway, the Army used TNET to evaluate VTT to deliver Reserve Component Basic Noncommissioned Officer Common Leader Training (RC BNCOC CLT) to Army Reserve and ARNG students at various sites within the State of Kentucky. The goal of this project was to compare the training and cost effectiveness of five training strategies:

1 Defense Institute for Training Resources Analysis (DITRA), *Florida Teletraining Final Report*, January 1994.

(1) Traditional instruction not reconfigured for VTT.

(2) Traditional instruction reconfigured for VTT.

(3) One-way video, two-way audio (1V, 2A) reconfigured for VTT.

(4) Two-way video, two-way audio (2V, 2A) reconfigured for VTT.

(5) 2V, 2A reconfigured VTT taught 8 hours a day for 7 days.

The TRADOC Analysis Command (TRAC) analysis[2] of training effectiveness indicated that:

a. Students in the 1V, 2A reconfigured VTT condition performed as well as students receiving traditional instruction that had been reconfigured for VTT. Thus, VTT can be used in lieu of traditional instruction.

b. Students in the 1V, 2A reconfigured VTT condition performed significantly better (.05 level) than students in the 2V, 2A group. One-way VTT can therefore replace the more costly 2V, 2A delivery of teletraining.

c. Students receiving traditional reconfigured instruction performed significantly better (.05 level) than students receiving traditional instruction that had not been reconfigured for VTT. This finding lends some support to the expert opinion found in industry and academia on the need to enhance traditional classroom instruction in preparation for VTT delivery.

d. Students in the 2V, 2A reconfigured VTT condition taught over a period of 7 days performed as well as students trained over a 4-month schedule. This finding indicates that there is no need to limit classes to 4 hours within a 24-hour period.

Army SEP Study. This study[3] considered 11 ALMC courses delivered in three forms: (1) residential courses at the ALMC site (Fort Lee); (2) on-site instruction by ALMC instructors traveling to remote locations; and (3) VTT. While the three instructional alternatives were equally effective, the cost per student-week using the satellite-delivered VTT was 25 percent less than the cost of resident training. (On-site delivery was less than half the cost of satellite delivery, but the study did not examine the issue of the availability of instructors to travel and provide on-site instruction.)

---

2 Wilson, Douglas, "Basic Noncommissioned Officer Course—Kentucky Reserve Component Video Teletraining," *Special Projects Branch Training Pilots*, Futures Training Division, Training Development and Analysis Directorate, U.S. Army HQ TRADOC, July 1992.

3 Redding, G.A., and Fletcher, J.D., "Technical and Administrative Issues in Distributed Training Technology," *Learning Without Boundaries*, Defense Research Series, Volume 5, Plenum Press, New York, 1994.

Army C&GS College Study. This study[4] compared post-course scores of four tests for one group of students who received residential instruction in the classroom and two groups of students who received instruction by VTT in two separate, remote classrooms. All students received the instruction at the same time. Scores of remote students were as good as the scores of resident students in one test, and they were significantly better in the other three.

Navy CESN Study. This study[5] found that grades in 13 courses were effectively identical for 178 students who received VTT and 178 other students who received resident instruction, but the VTT alternative saved an average of $386 for each of the VTT students.

Army ALMC Study. This study[6] considered a single course delivered in three modes of instruction: (1) resident training; (2) on-site instructors; and (3) VTT via satellite in two forms, analog video and compressed digital video (CDV). The cost per student was $2,012 for resident training, $877 for on-site instructor training, $611 for analog satellite, and $419 for CDV satellite transmission, or savings of 56 percent, 70 percent, and 79 percent, respectively, over resident training.

---

4 Ibid.'

5 Ibid.

6 Ibid.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. AGENCY USE ONLY *(Leave blank)*

2. REPORT DATE
December 1996

3. REPORT TYPE AND DATES COVERED
Final—August 1995–November 1996

4. TITLE AND SUBTITLE
Distance Learning and the Reserve Components

5. FUNDING NUMBERS
DASW01 94 C 0054
T-L2-1374

6. AUTHOR(S)
J. Metzko, G.A. Redding, J.D. Fletcher

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Institute for Defense Analyses
1801 N. Beauregard St.
Alexandria, VA 22311-1772

8. PERFORMING ORGANIZATION REPORT NUMBER
IDA Document D-1941

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of the Under Secretary of Defense (Personnel and Readiness)
Readiness and Training Directorate
Room 3B930, The Pentagon
Washington, DC 20301

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited. 3 February 1997.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 180 words)*
This report summarizes and evaluates Service plans to adopt distance learning (DL) technologies submitted in response to tasking by the Deputy Secretary of Defense. The evaluation includes consideration of information exchanged in joint-Service/OSD (Office of the Secretary of Defense) groups that have been reviewing Service training requirements and training technology. The evaluation of DL plans resulted in the following major findings: (1) DL has the potential to provide effective training and to reduce costs; (2) DL is little used by DoD today; (3) converting to DL requires sizable up-front investments; (4) the Services plan to convert about one in five courses to DL; (5) joint management of DL is needed to maximize savings; and (6) data gaps preclude intelligent DL investment decisions.

14. SUBJECT TERMS Computer-aided instruction, computer-based instruction, computer-based training, computer-managed instruction, distance learning, distance training, distributed training, interactive videodisc, military training, reserve components, Service training, training cost, training effectiveness, training requirements, training technology, video teletraining

15. NUMBER OF PAGES
78

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	SAR

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)
Prescribed by ANSI Std. Z39-18
298-102